PLANT CELL BIOLOGY AND DEVELOPMENT

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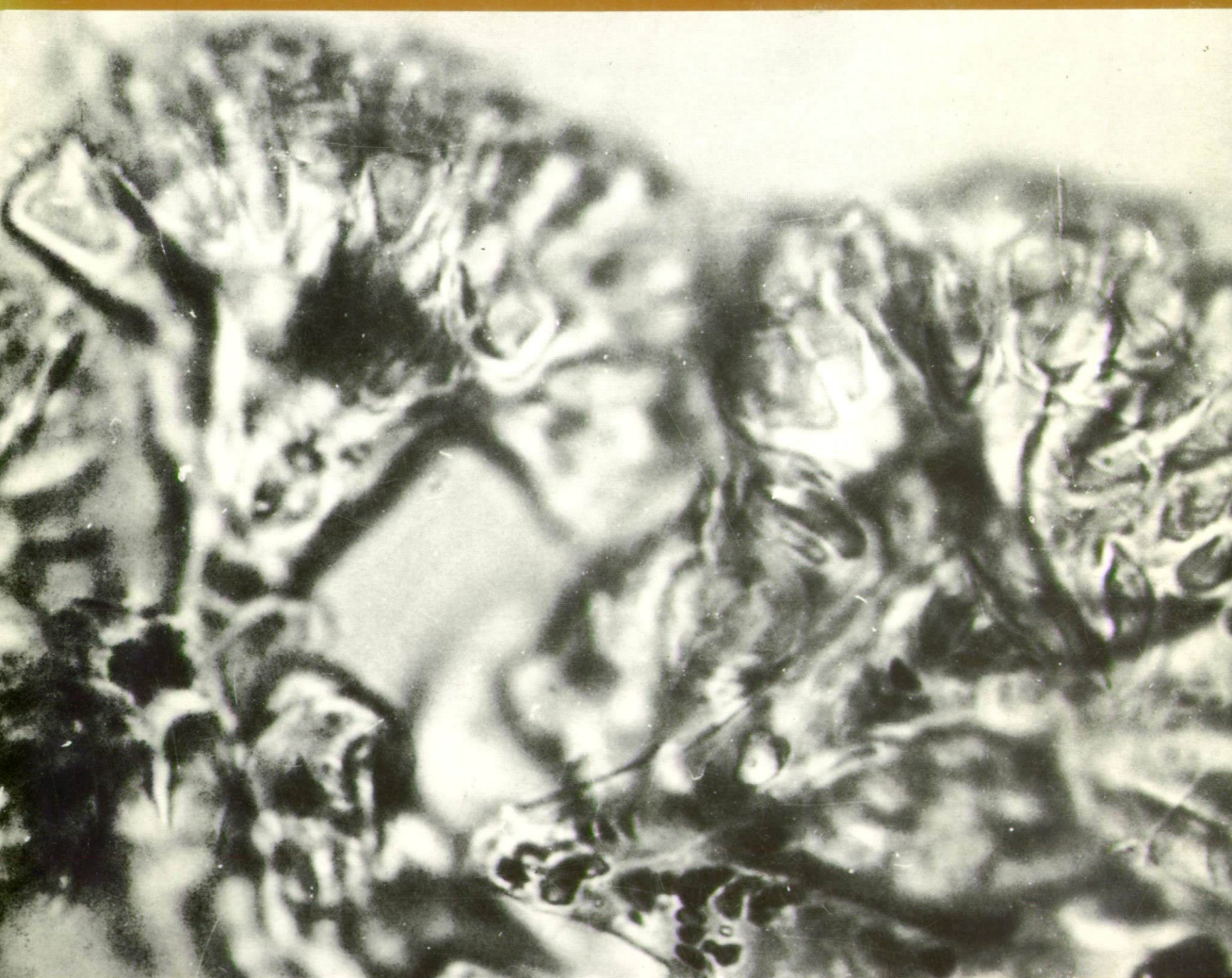
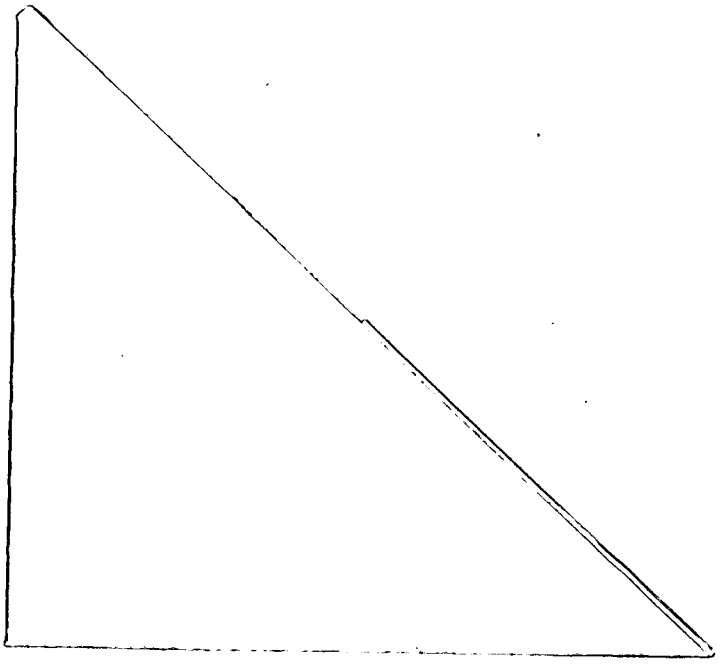
M. KEDVES





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Preface

This number of the laboratory publications is dedicated to the Tenth Anniversary of the Discovery of the Quasicrystals. I hope, that the presented papers herein represents well the aim of our effort, namely the following:

i. The inter- and/or multidisciplinary researches in our fields.
ii. The adaptation of the methods of other fields of researches.
iii. In the same time to continue so-called classical researches with classical methods, but with the complentation of the newest molecular or biophysical concepts.

The discovery of the quasicrystals and the fullerenes are very important to the research programs of our laboratory. The last years, and it seems in the future we will carry out several experimental studies with the concept of the quasi-crystalloid skeleton of the plant cell wall and/or of the cytoskeleton too.

This number was published by the financial support of several institutions. I would like to express my sincere thanks to the following persons and institutions:

to Prof. Dr. GY. TELEGDY member of the Hungarian Academy of Sciences,

to the Foundation for the Science of the South Hungarian Plain,

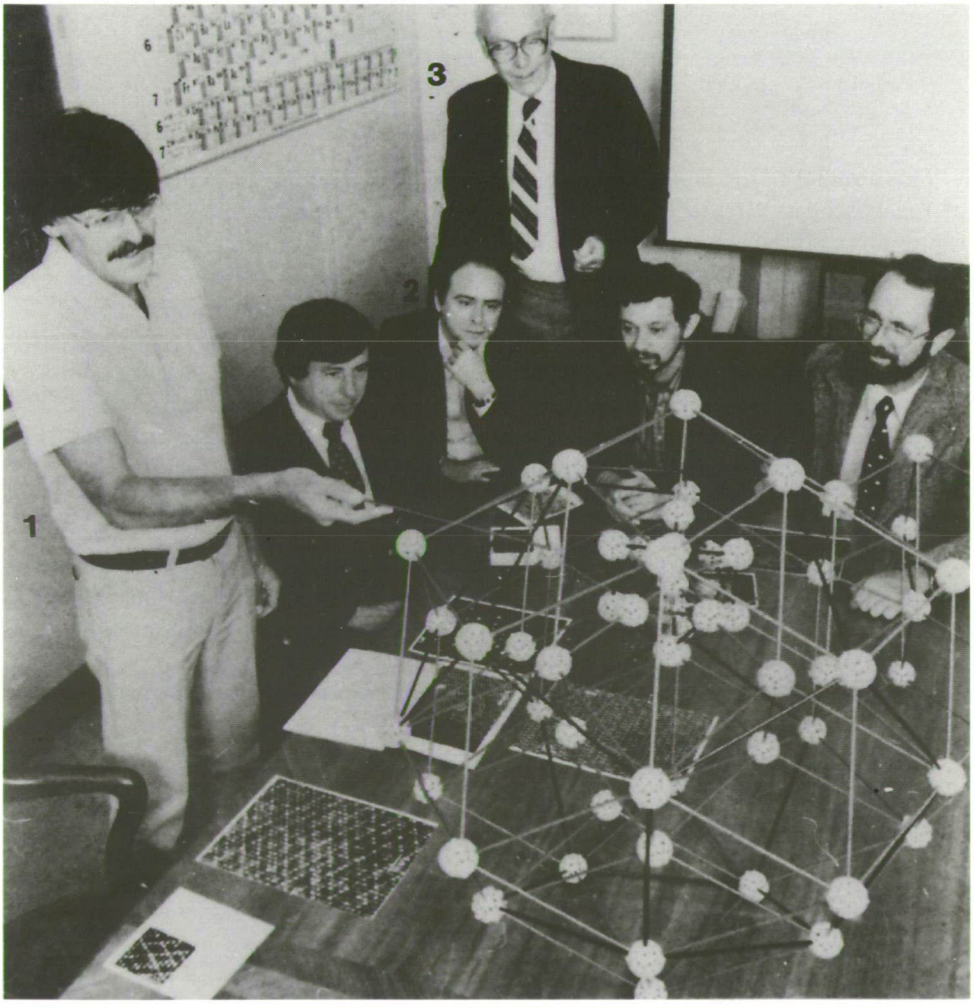
to the Scientifical and High-educational Committee of the Local Government of Szeged,

to Prof. Dr. I. DÉKÁNY scientifical vice-rector of the J. A. University, and Prof. Dr. R. MÉSZÁROS, Dean of the Faculty of Science,

to the Foundation of the Grant OTKA 1/3–104.

Szeged, 25 February 1994.

M. KEDVES
head of the laboratory



Group of scientists with three of the discoverers of quasicrystals, Dan SHECHTMAN (1), Denis GRATIAS (2) and John W. CAHN (3). The picture was taken from a NIST publication (1988), and it does not include Professor Ilan BLECH. The picture was made available for us by courtesy of Dan SHECHTMAN, the reproduction was made by Dr. I. BAGI.

TO THE TENTH ANNIVERSARY OF THE DISCOVERY OF QUASICRYSTALS

M. KEDVES

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It was ten years ago that SHECHTMAN, BLECH, GRATIAS and CAHN published rapidly cooled AlMn alloy that gave diffraction patterns with full icosahedral symmetry. This discovery indicated an extremely intensive research in several fields of Crystallography, Physics, Mathematics, etc.

Several handbooks have been published and synopsia have been organized on this problem and with its inter- or better say multidisciplinary character and connections. The number of the papers published on the new results is enormous, it is extremely difficult to enumerate only the most important steps in this field of research during the last few years. Some selected examples may be mentioned as follows.

1989 – Symmetry of structure. An interdisciplinary Symposium (Abstracts in two volumes, edited by GY. DARVAS and D. NAGY).

1990 – Quasicrystals, Network, and Molecules of Fivefold Symmetry. VCH Publishers, Inc. New York, I. HARGITTAI editor; contributors: A. L. MACKAY, M. SENECHAL, R. Z. SAGDEEV and G. M. ZASLAVSKY, PENG JU LIN and L. A. BURSILL, F. DÉNOYER, G. HEGER and M. LAMBERT, R. A. DUNLAP, D. W. LAWTHER and V. SRINIVAS, J.-P. ALLOUCHE and O. SALON, E. J. W. WHITTAKER and R. M. WHITTAKER, M. BAAKE, P. KRAMER, M. SCHLOTTMANN and D. ZEIDLER, P. MCMULLEN, H.-U. NISSEN. P. STAMPFLI, P. G. MEZEY, D., J. KLEIN and T. G. SCMALZ, A. LÉGER, L. D'HENDECOURT, L. VERSTRAETE and W. SCHMIDT, E. BRENDSDAL, S. J. CYVIN, B. N. CYVIN, J. BRUNVOLL, D. J. KLEIN and W. A. SEITZ, V. ELSER, E. BRENDSDAL, S. J. CYVIN, J. BRUNVOLL, B. N. CYVIN and D. J. KLEIN, E. BRENDSDAL, J. BRUNVOLL, B. N. CYVIN and S. J. CYVIN, D. KUCK.

1991 – Topics on contemporary Crystallography and Quasicrystals, Special Issue, Periodico di Mineralogia. Edited by L. LORETO and M. RONCHETTI; contributors: M. V. JARIC, H.-U. NISSEN and C. BEELI, S. MERLINO, M. EMMER, R. PENROSE, L. H. TANG, M. RONCHETTI, C. ANTONIONE, L. BATTAZZATI, M. CALLERI and F. MARINO, A. L. MACKAY, L. LORETO, R. FARINATO and F. PAPPALARDO, A. L. LOEB.

M. RONCHETTI compiled the bibliography of Quasicrystals.

1991 – Symmetry and Topology in Evolution, edited by B. LUKÁCS, SZ. BÉRCZI, I. MOLNÁR and G. PAÁL.

1992 – Szimmetria – Aszimmetria, edited by T. BALOGH, MTA SZAB.

After these examples, let me make a short list of the most important results of our laboratory concerning quasicrystals in the field of Cell Biology.

1988 – Discovery of the quasicrystalloide biopolymer structure in living system on partially degraded exine of *Pinus griffithii* McCLELL..

1989 – A modified MARKHAM rotation method was elaborated to investigate the symmetries of the basic quasi-crystalloid skeleton of the plant cell wall. Highly organized biopolymer structures were described with quasi-crystalloid basic units. A comprehensive model of the biopolymer organization of the sporoderm was established. Three major degrees were distinguished at the highly organized biopolymer system of the sporoderm.

1990 – The first TEM picture was published about the PENROSE unit-like biopolymer unit from the partially degraded exine of *Pinus griffithii* McCLELL obtained with the secondary rotation method. The first data about the biopolymer structure of partially degraded wall of the spores of the genus *Selaginella.*

1991 – The first observations of the biopolymer structure of the intine. Biopolymer units of hexagonal symmetry were described. Data about the superficial molecular system of the pollen wall. Highly organized globular biopolymer units from the partially degraded and fragmented wall of *Botryococcus braunii* KÜTZ. extracted from the Hungarian oil shale were published. These units can be modelled with fullerenes, which are quasi-equivalent biopolymer structures. Quasi-crystalloid biopolymer structures were described from explosive dangerous Jurassic coal pulver. Quasi-crystalloid biopolymer structures were published from partially degraded and fragmented sclereids of *Armeniaca vulgaris* LAM. Three-dimensional modelling of the biopolymer skeleton of the plant cell wall.

1992 – Secondary alterations in the biopolymer structure of the exine as a consequence of the X-ray effect. The first data about the stabilizing system of the quasi-crystalloid biopolymer skeleton of the sporoderm.

1993 – "Negative" quasi-crystalloid biopolymer network was described from the partially degraded exospore of *Equisetum arvense* L. The radial rotation method was introduced with the alterations of the outer and inner rotation areas as a new two-dimensional method.

In resumé, the inter- or multidisciplinary principles can result several new aspects in the so-called "classic" scientific fields. The new research fields of Crystallography have opened new aspects and prospects in Cytology, and in the investigations of fossil organic material. At the recent investigation material, not only the biopolymers of the plant cell wall can be investigated with the new research concepts and methods, but also the cytoskeleton and all kinds of organelles of living systems. The discovery of quasicrystals was an extremely important contribution to this new research on recent and fossil plant organelles.

1. LM INVESTIGATIONS OF DIFFERENT STAINED FOSSIL BOTRYOCOCCUS COLONIES

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Abstract

Colonies of the *Botryococcus braunii* KÜTZ. algue extracted from the Upper Tertiary oil shale of Pula (Hungary) were investigated with the light-microscope. Stained, non-stained and solvated colonies were the subjects of these researches. The stain acceptance is suitable for researches of this kind, too, to establish the degrees of maturity of the organic components of the colonies.

Key words: Botryococcus braunii, oil shale, Neogene, stain acceptance, Pula, Hungary.

Introduction

The basic morphology of the genus of the *Botryococcus* KÜTZ. is extremely peculiar and isolated in the Plant Kingdom. This is the reason why the taxonomic position has been widely discussed and changed. This genus was ranged with the *Heterocontae* (KISS, 1939) respectively within the the *Chlorophyceae* WILLE (in ENGLER and PRANTL, 1910). Morphological statements by FREMY and DANGEARD (1938) and CHADEFAUD and EMBERGER (1960), COMBAZ (in DURAND, 1980) and GLIKSON, LINDSAY and SAXBY (1989). Resuming the basic morphology is as follows (Plate 1.1.).

1. The colonies are enveloped in mucilage (= Schleimmasse = mucilagineuse = une enveloppe gelatineuse hyaline = hydrocarbon matrix).
2. The differentiations of the cellular components of the colonies are: pedunculus, cupula. The individuum are in pair in the cupula and are forming one "polipier" sensu CHADEFAUD and EMBERGER (1960).
3. COMBAZ (1980) (Cf. CHADEFAUD and EMBERGER, 1960), published a scheme about the organelles of the protoplasm (nucleus, amidon, oil drops, plastis). An important component is the cuticle cellular. The cuticle of the mother cell is a part of the basal region of the "polipier" (Plate 1.1.). The morphology of the pedunculus is very characteristic. (Plate 1.1., 1.2.)

TEM data about fossil *Botryococcus* colonies from the oil shale were published by KEDVES (1983) and GLIKSON, LINDSAY and SAXBY (1989). The oil reservoir function of the holes in mucilage and in the more or less compact wall substance of the fossil colonies was pointed out (KEDVES, 1983). Biopolymer organization (KEDVES, 1988)

and thin layer chromatography was first described in two papers from the locality of Pula (KEDVES, 1986a, b).

Concerning the ecology of the *Botryococcus braunii* KÜTZ. algue the following can be pointed out:

i. Occurence in eutrophic fresh water or in humid soil (WILLE, in ENGLER and PRANTL, 1910) in Europe, North America and Africa. These colonies can also be present in salt lakes or in the water of marine lagoons.

ii. Stenotherm species after the paper of KISS (1939). The geological distribution of this kind of algue is extremely large. JARZEN (1978) wrote the following, p. 32: *"Botryococcus* KÜTZING (Pl. 1, fig. 3) is a colonial green algae, whose colonies form irregular globose masses encasted in a heavy, often dark, cohered mucilage. TRAVERSE (1955) have reviewed the fossil occurences of the genus and notes that the fossil record probably extends back at least to the Ordovician." (Cf. NARAYANA RAO and MISRA, 1949).

"The hydrocarbon secreting alga *Botryococcus* has been identified in organic remains of sediments ranging from Precambrian to Recent," (GLIKSON et al., 1989, p. 595).

Taking into consideration several results the chemical compositions of the fossil forms is determined by the following factors:

1. The basic composition of the different cellular elements of the colonie.
2. The ontogenetical state of the algue.
3. The molecular alterations in the wall also during the life.
4. The fossilization of the algue.
5. Taphonomical processes.
6. The preservation in the sediments.

The aim of this research is complex. By the LM method and the stain acceptance to get information, about the maturity of the different part of the colonies (Cf. POTONIÉ and REHNELT, 1971). The advantage of the light-microscopy combined with cytochemical methods is that a mass of data can be obtained. The statistical evaluation of the great number of information is important from the point of view of the Ontogenesis, Ecology, and Taphonomy.

Materials and Methods

The material of investigation is an average sample from the oil shale deposits of Pula (Hungary, Transdanubia). The oil shale of Transdanubia (Hungary) was first discussed by JÁMBOR and SOLTI (1975). Following JÁMBOR (1980) there are peculiar geological and paleoenvironmental conditions during the formation of these volcanic lakes. The water of the lakes is oligohaline water. The Geology (Cf. JÁMBOR, 1980, HETÉNYI, 1985, JÁMBOR and SOLTI, 1975, SOLTI, 1981), Ecology (Cf. NAGY, 1976, HAJÓS, 1976) and Geochemistry (HETÉNYI, 1985, 1987–1988, HETÉNYI and PÁPAY, 1986, ARATÓ and BELLA, 1976) of the oil shale was the subject of several investigations. The most important statements are as follows:

1. The investigated oil shale is a volcanic lake type. (JÁMBOR and SOLTI, 1975, JÁMBOR, 1980). 2. There was a geysirite activity during the sedimentation of the

alginite (SOLTI, 1981). 3. The water was oligohaline 0.3%, indicated by the diatoms published by HAJÓS (1976). 4. The clima was warm-temperate (annual average temperature: 10–12 °C), following HAJÓS (1976). E. NAGY (1976) described the pollen grains of Mediterranean conifers. 5. The water depth was some meters only based on the benthonical algues (Cf. HAJÓS, 1976). 6. The riparian Woodland resulted a peculiar local clima (E. NAGY, 1976). 7. The above mentioned conditions resulted the water flowering with the *Botryococcus braunii* forming the alginite.

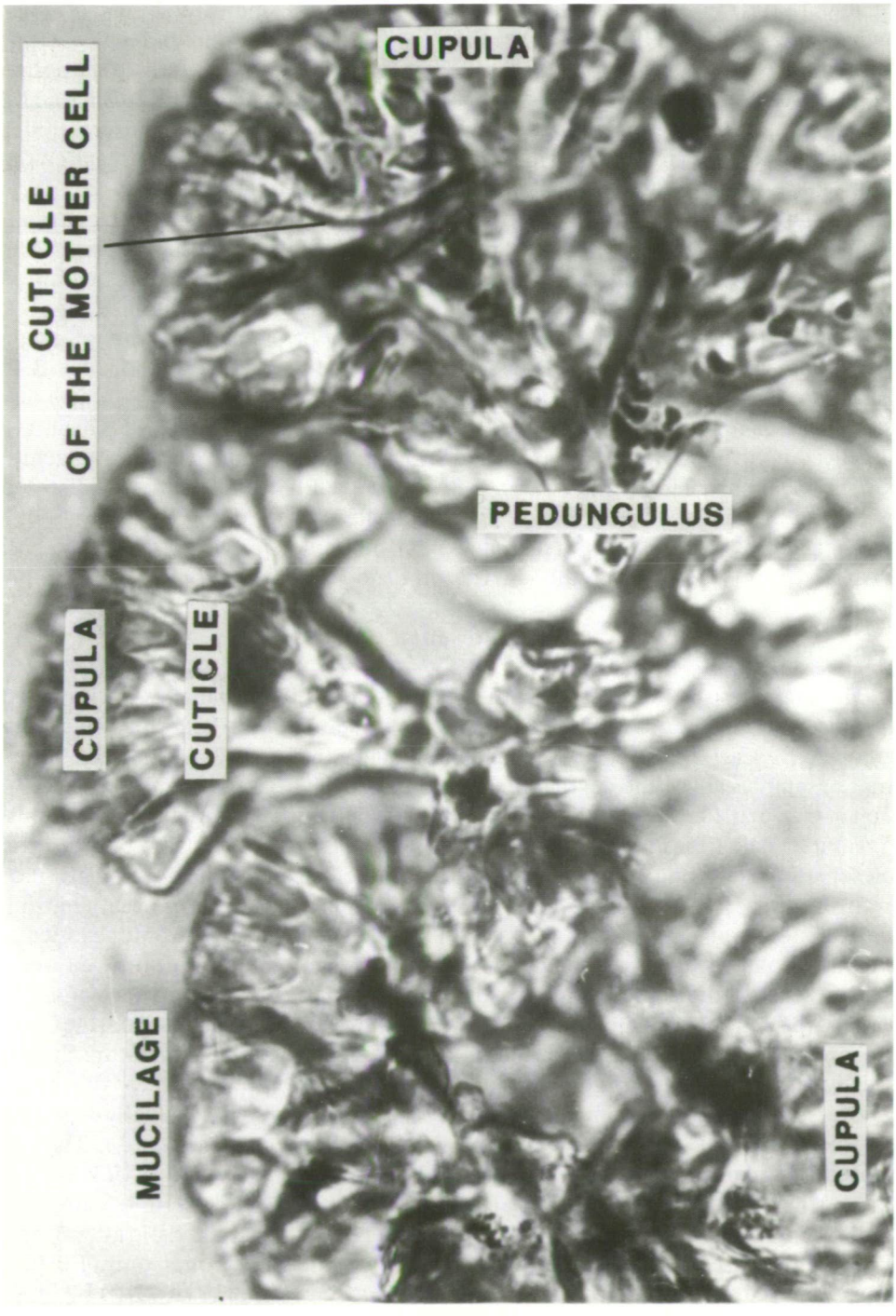
The pulverized material was mixed with water. After stirring the inorganic components settled down and the organic fraction was separated, and newly dried. The investigation was prepared as follows. 1. Intact colonies (after separations mounted in glycerin-jelly hydrated at 39.6%). 2. Colonies partially dissolved with methanol. 3. To get information about the alterations or maturity of the colonies the following stains were used: 3. 1. BISMARCK Brown (vesuvin) 1% dissolved in ethanol 30%. 3. 2. BISMARCK Brown (vesuvin) 1% dissolved in ethanol 70%. 3. 3. Chrysoidin 2% dissolved in ethanol 40%. 3. 4. Safranine T 2% dissolved in ethanol 50%. 3. 5. Eosin 1% dissolved in distilled water. 3. 6. Fe-Haematoxylin (after EHRLICH). 3. 7. Malachite Green 1% dissolved in distilled water. 3. 8. Methylene Blue 1% dissolved in distilled water. 3. 9. Toluidine Blue 0.2% dissolved in distilled water.

The pictures were taken with an objective of oil immersion; Carl Zeiss Jena, GF Planachromat HI 100x/1.25∞/0.17–A, except, Plate 1.1.

Results

The characteristic morphology with the different cellular organelles is illustrated in Plate 1.1. The pictures were taken from colonies stained with Toluidine Blue, with an objective Carl Zeiss Jena, GF Planachromat 40x/0.65∞/0.17–A. Plate 1.2. illustrates examples about the degradation and the kerogen accumulation. The description of the detailed results is given in the order under the title Materials and Methods.

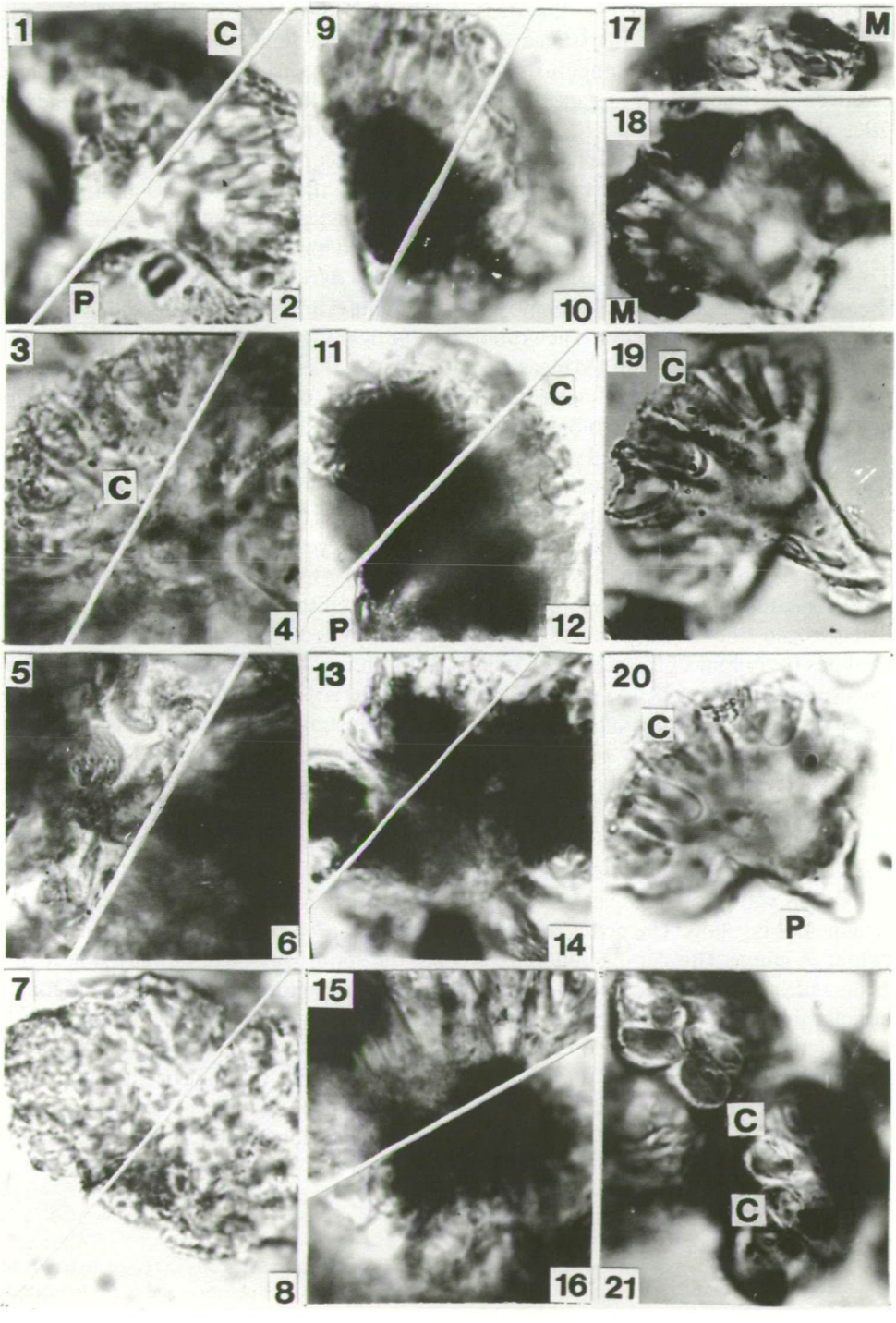
1. Intact colonies (Plate 1.2., figs. 3,4, and 13,14). It is a relationship between the preservation stage and geochemical maturity of the colonies. The accumulation of kerogen may be indicator of the "maturity level." In the case of kerogen accumulation, the colonies are at least partially degraded (Plate 1.2., figs. 13,14). The ontogenetically primitive colonies are less degraded in contrast to the completely developed ones. The presence of the green granules is also an indicator of the maturity level. On the basis of the data of the material of Pula the following can be distinguished. 1. 1. Clear greenish-yellow, semi-transparent colonies without kerogen accumulation and/or green granules. 1. 2. Clear greenish-yellow to brownish-yellow colonies with green granules. Colonies of this kind may be degraded to some level. 1. 3. Partially degraded colonies containing kerogens (brown particles), and green granules. 1. 4. The advanced degradation process is well shown with relatively high quantity of kerogens and green granules. 2. Colonies partially dissolved with methanol (Plate 1.2., figs. 7,8, and 9,10). The preliminary investigations did not result in characteristic alterations. The colonies are more transparent in contrast to the intact ones only. Further experiments are necessary with this solvent. 3. Stained colonies (Plate 1.1., 1.2., figs. 1,2,5,6, 11,12, 15–21). In comparison to the intact colonies the following characteristic


CUPULA
CUTICLE
OF THE MOTHER CELL
PEDUNCULUS
CUPULA
CUTICLE
MUCILAGE
CUPULA

features were investigated by the stained material: the green granules; the brown particles of the kerogen; the stain acceptance of the mucilage; the different particles of the cupula and the pedunculus. Particular attention was paid to the degradation surfaces. 3.1. and 3.2. BISMARCK Brown (vesuvin) 1% dissolved in ethanol 30% and 70% (Plate 1.2., figs. 1,2,11,12). No significant differences were found between the two kinds of dissolved stains. The colonies have not accepted this stain but the solvent effect of the ethanol was observed which is similar to those of the methanol (2.) 3.3. Chrysoidin 2% dissolved in ethanol 40% (Plate 1.2., fig. 20). The inner regions of the wall respectively the cupula and the pedunculus accepted this stain but only at the well preserved colonies. The colour is orange occasionally dark orange, or yellow. Worth of mentioning is the unstained part of the wall. The granules are stained at the well preserved colonies in a middle per cent. The granules of the degraded colonies have not accepted the stain or only to a very limited measure. The colour of the completely damaged colonies is yellow. No colour change was observed at the brown particles and the mucilage, in contrast to the non-stained colonies. 3.4. Safranine T 2% dissolved in ethanol 50% (not illustrated). The not degraded wall have accepted the stain only in a very poor measure. The degradations surfaces much better accepted the stain. The granules accepted occasionally the stain. The mucilage well accepted the stain in this way, its colour is red. The pedunculus is in general yellow, in this way this is the original colour. But the cupula have accepted partially the stain, the colour may be yellow or red. 3.5. Eosin 1% dissolved in distilled water (Plate 1.2., figs. 15,16). The wall accepted the stain, the colour is orange. The kerogen (the brown particles) is as at the non stained material. At some degraded colonies the colour of the cupula is orange. But in general it seems that the cupula and the pedunculus have not accepted the stain. The colour is as originally. The mucilage also accepted this stain. 3.6. Fe-Haematoxylin (after EHRLICH) (not illustrated). The slide colour changed; after a certain time to yellow. The colour of the wall is grey or greyish-blue. The cupula accepts the stain much more than the pedunculus. The colour of the pedunculus is originally yellow. The granules are green or occasionally bluish-violet. The colour of the kerogen has not changed; brown. 3.7. Malachite Green 1% dissolved in distilled water (not illustrated). The colour of the pedunculus at the well preserved colonies is yellow or transparent. At the partially degraded colonies the colour of the pedunculus is yellow. The pedunculus accepts the stain at the degraded specimens so the colour is green. The cupula generally accepts the stain. But exceptionally, when the pedunculus has not accepted the stain, the colour is yellowish-green. The mucilage accepts the stain very well, its colour is dark green. Kerogen accepts the stain. 3.8. Methylene Blue 1% dissolved in distilled water (Plate 1.2., figs. 17,18). The wall does not accept the stain in contrast to the granules. The outer part of the cupula is blue, the inner part is yellow. The pedunculus is yellow only rarely accepts the stain. The kerogen accepts the stain. 3.9. Toluidine Blue 0.2% dissolved in distilled water (Plate 1.1., 1.2., figs. 19,21).

◂ Plate 1.1

Botryococcus braunii KÜTZING from Alginite of Pula. General aspect from well preserved colonies from the Upper Neogene of Pula. Coloured with Toluidine Blue. The different cellular organelles are indicated. 1200 x.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The colonies accept the stain, the colour is green. This indicates the accumulation of the aromatic lignin derivates. The granules rarely accept the stain, at the well preserved colonies. At the degraded specimens the granules have been colored. The mucilage accepted the stain, colour: violet. The cupula is at the well preserved colonies green or greenish-yellow. The pedunculus is mostly violet. The colour of the degraded colonies and the kerogen is also violet.

Discussion and Conclusions

In consequence of the polycondensation and polymerisation during the diagenesis the kerogen is three dimensional network of organic molecules. The chemical composition has been investigated by several laboratories. From the very extensive data of a mass of publications the following citations will be pointed out.

DOUGLAS, EGLINGTON and MAXWELL (1969), p. 569: "The hydrocarbon content of coorongite, a Recent rubbery deposit derived from the alga *Botryococcus braunii,* has been investigated by infrared spectrometry, gas chromatography and combined gas chromatography-mass spectrometry."

ANDERS and ROBINSON (1971), p. 661: "Fifty-two cyclic alkanes, isolated from the bitumen of Green River shale, were analyzed by mass spectrometry."

The acceptance of the stains well indicates the heterogenity of the colonies. Namely the colonies of different "maturity" and degradation level differentially accept the stains. The differences in the degree of the maturity well shown at the coloration with the Chrysoidin. The differences in the degradation level were demonstrated with the coloration of the Toluidine Blue, Safranine T and Malachite Green. Less expressed are the following stains: Chrysoidin and Eosin. Kerogen well accepted Safranine T, Malachite Green, Methylene Blue and Toluidine Blue. This fact indicates the presence of the aromatic derivates. The pedunculus accept less the stains in contrast

◂ Plate 1.2.

1–21. *Botryococcus braunii* KÜTZING from Alginite of Pula. 1000 x.
1,2. Well preserved colony coloured with Vesuvin.
3,4. Unstained slightly degraded colony with green granules.
5,6. Partially degraded colony stained with Eosin.
7,8. Completely degraded unstained colony, dissolved with methanol.
9,10. Kerogen accumulation at the basical part of the colony. Unstained material dissolved with methanol.
11,12. High measure of kerogen accumulation stained with Vesuvin (dissolved in ethanol 30%).
13,14. Unstained colony. The accumulation of the kerogen extends near to all parts of the colony. Unstained material.
15,16. The kerogen accumulation is at basis of the colonies. Stained with Eosin.
17,18. Well shown is the mucilage coloured with Methylene Blue.
19. The peculiar morphology of the pedunculus. The granules are coloured with Toluidine Blue.
20. Well preserved colony stained with Chrysoidin.
21. The granules coloured with Toluidine Blue.

C = cupula, M = mucilage, P = pedunculus.

to the cupula. Chrysoidin and Toluidine Blue coloured in an important measure the pedunculus. Malachite Green and Methylene Blue at the degraded colonies have coloured the pedunculus. It is necessary to point out that Toluidine Blue coloured the colonies in a different way. The colour of the cupula at well preserved colonies is green. The colour of the degraded cupules is violet. Methylene Blue coloured the outer part of the cupula. (Cf. CHADEFAUD and EMBERGER, 1960). The green granules have not totally accepted the stain. The stain acceptance was moderated at Chrysoidin, Toluidine Blue and Methylene Blue. In a very poor measure Safranine T, and Fe-Haematoxylin have coloured the green granules.

Resuming this was useful for several points of views. But it is necessary to develop this methodical concept, too. For this it is necessary to investigate the mechanism of the different coloration.

Acknowledgements

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Appendix

GUY-OHLSON, D. (1992): *Botryococcus* as an aid in the interpretation of paleoenvironment and depositional processes. – Rev. Palaeobot. Palynol. *71,* 1–15.

2. DOROG TYPE (MIDDLE EOCENE) SPORE-POLLEN ASSEMBLAGE IN THE SOCKA BEDS OF SLOVENIA I.

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Abstract

During our multidisciplinary studies of the problem of the Oligocene and Lower Miocene stratigraphy in Slovenia, we have established the following: 1. The Socka Beds are heterochronous. 2. The type locality is of Middle Eocene age. 3. The tropical coal forming vegetation was reconstructed on the basis of palynological data. 4. The dominance of the pollen grains associated with spores of tropical ferns (*Anemia, Lygodium, Gleicheniaceae,* etc.) is identical with the Dorog Basin type. This result changes the previous paleophytogeographical concepts on this subject.

Key words: Palynostratigraphy, Paleophytoecology, Paleophytogeography, Middle Eocene, Slovenia.

Introduction

The lithostratigraphic term Socka Beds (Sotzka-Schichten) was introduced by ROLLE in 1858.

The Socka Beds stratigraphic position has never been succesfully solved. Namely, stratigraphers found themselves in persistent contradictions as they stated whether at different sites or all embracingly, the Latdorfian (Lower Oligocene), the Rupelian (Middle Oligocene), the Egerian, the Helvetian (Ottnangian to Karpatian) age of the Socka Beds, or even vaguely supposed their Eocene age. If we carefully consider the existing literature, it becomes obvious that every work and in particular every rearrangement to accomodate the Socka Beds stratigraphic position to new developments in the chronostratigraphic scale, for example to the establishment of Oligocene or to the proposal of new Paratethian stages, only apparently moved the problem closer to the solution. But, in fact they only added to the confusion concerning the age and the correlation of the Socka Beds in their own way.

The aim of this paper is to present the most important sporomorphs from four localities: Socka, Dobrna, Velenje and Lepena in the Southern Karavanke, and of their comparison with the Transdanubian assemblages in Hungary.

Results

DINOPHYCEAE

Cordosphaeridium cf. *spinosum* var. *deflandrei* (LEJ.-CARPENTIER 1941) DE CON. 1965 (Plate 2.1., figs. 1,2), *C.* cf. *tiara centrocarpum* (DEFL. and COOKS. 1955) MORG. 1966 (Plate 2.1., figs. 3,4), *Glaphyrocysta* v. *Geridocysta* sp. 1 (Plate 2.1., figs. 5,6), *Glaphyrocysta* v. *Geridocysta* sp.2 (Plate 2.1., figs. 7,8).

PTERIDOPHYTA

LYCOPSIDA

Lycopodium v. *Selaginella.* – *Zlivisporis dorogensis* (KDS. 1965) PACLT. and SICS. 1970 (Plate 2.2., fig. 3).

Selaginellaceae, *Selaginella.* – Cf. *Echinatisporis longechinus* W. KR. 1959 (Plate 2.1., fig. 18).

PTEROPSIDA

Osmundaceae. – *Baculatisporites ovalis* KDS. 1973 (Plate 2.2., fig. 2).

Schizaeaceae

Cf. *Lygodium.* – *Leiotriletes dorogensis* (KDS. 1960) KDS. 1961 fvar. *triplan* (Plate 2.1., fig. 9), *Leiotriletes adriennis* (R. POT. and GELL. 1933) W. KR. 1959 (Plate 2.1., fig. 10), *Leiotriletes microadriennis* W. KR. 1959 (Plate 2.1., fig. 11).

Anemia. – *Cicatricosisporites dorogensis* (R. POT. and GELL. 1933) subfsp. *dorogensis* (Plate 2.1., fig. 9, plate 2.2., figs. 4,5).

Gleicheniaceae

Toroisporis (Toroisporis) teuplitzenensis W. KR. 1962 subfsp. *mediocris* W. KR. 1962 (Plate 2.1., figs. 13,14), *Toroisporis (Toroisporis) guineti* KDS. 1973 (Plate 2.1., fig. 15), *Concavisporites (Concavisporites) hungaricus* KDS. 1973 (Plate 2.1., figs. 16,17).

Pteridaceae

Polypodiaceoisporites bauxitus KDS. and J. RÁK. 1965 (Plate 2.2., figs. 6,7), *Polypodiaceoisporites undulosculptatus* KDS. 1973 (Plate 2.2., fig. 8), *Polypodiaceoisporites marxheimensis* (MÜRR. and PF. 1952) W. KR. 1959 (Plate 2.2., figs. 19,20), *Segmentizonosporites palaeogenicus* KDS. and J. RÁK. 1965 (Plate 2.2., figs. 11,12).

Polypodiaceae

Laevigatosporites haardti (R. POT. and VEN. 1934) TH. and PF. 1953 subfsp. *haardti* (Plate 2.2., fig. 15), *Verrucatosporites favus* (R. POT. 1931) TH. and PF. 1953 subfsp. *favus* (Plate 2.2., figs. 16,17).

INCERTAE

Punctatisporites luteticus W. KR. 1959 (Plate 2.1., fig. 12), *Trilites* fsp. (Plate 2.2., figs. 13,14), *Psophosphaera reissingeri* (KDS. 1961) KDS. 1974 (Plate 2.2., figs. 24,25).

GYMNOSPERMATOPHYTA

Cycadopsida, Ginkgoaceae v. Cycadaceae. – *Cycadopites kyushuensis* (TAKAHASHI 1961) KDS. 1968 (Plate 2.3., figs. 1,2)

Coniferophytina

?Abietaceae, Pseudotsuga v. Larix. – Cf. *Psophosphaera* fsp. (Plate 2.2., figs. 22,23).

Taxodiaceae v. Cupressaceae. – *Inaperturopollenites concedipites* (WODEH. 1933) W. KR. 1971 (Plate 2.2., fig. 1).

Araucariaceae
Araucariacites balinkaense KDS. 1974 (Plate 2.2., figs. 20,21).
? Coniferophytina
Cupressacites dorogensis (KDS. 1961) KDS. 1974 (Plate 2.2., figs. 26,27).
Reworked *gymnosperm* pollen grain. – *Alisporites* fsp. (Plate 2.2., figs. 18,19).
ANGIOSPERMATOPHYTA
DICOTYLEDONOPSIDA
Fagaceae. – *Fususpollenites fusus* (R. POT. 1934) KDS. 1978, *Fagaceae* (Plate 2.3., figs. 19,20).
Myricaceae. – *Plicapollis pseudoexcelsus* (W. KR. 1958) W. KR. 1961 subfsp. *turgidus* PF. 1953 (Plate 2.3., figs. 27,28).
Juglandaceae. – Cf. *Platycaryapollenites* fsp. (Plate 2.3., figs. 29,30), *Plicatopollis lunatus* KDS. 1974 (Plate 2.3., figs. 31,32), *Plicatopollis hungaricus* KDS. 1974 (Plate 2.3., figs. 33,34), *Plicatopollis krutzschi* KDS. 1974 (Plate 2.3., figs. 35,36).
Icacinaceae. – *Compositoipollenites rhizophorus* (R. POT. 1934) R. POT. 1960 subfsp. *rhizophorus* (Plate 2.3., figs. 39,40).
Elaeagnaceae v. Simarubaceae. – *Pentapollenites laevigatus* W. KR. 1962a subfsp. *laevigatoides* W. KR. 1962a (Plate 2.3., figs. 25,26).
Aquifoliaceae. – Cf. *Ilexpollenites erdtmani* KDS. 1978 (Plate 2.3., figs. 15,16).
Bombacaceae. – *Bombacacidites* fsp. (Plate 2.3., figs. 37,38).
Sapotaceae. – *Tetracolporopollenites urkuticus* KDS. 1978 (Plate 2.3., figs. 21,22).
Calyceraceae. – *Intragranulitricolporites tumescens* (KDS. 1964) KDS. 1978 (Plate 2.3., figs. 17,18).
Incertae. – *Eocaenipollis* fsp. (Plate 2.3, figs. 23,24).
MONOCOTYLEDONOPSIDA
Palmae. – *Monocolpopollenites tranquillus* (R. POT. 1934) TH. and PF. 1953 subfsp. *tranquillus* (Plate 2.3., figs. 3–6).
Nipa. – *Spinizonocolpites* cf. *prominatus* (MCINTYRE 1965) KDS. 1974 (Plate 2.3., figs. 7,8), cf. *Nipa.* – *Spinizonocolpites* fsp. (Plate 2.3., figs. 9–12).
North African Upper Cretaceous reworking: *Proxapertites africanus* KDS. nom. nud. (Plate 2.3., figs. 13,14).

Conclusions

1. The presented spore-pollen assemblage is identical with the Middle Eocene "Dorog type" of Hungary.
2. So far the Middle Eocene age is restricted to the coal bearing strata at Socka, Dobrna, Velenje and Lepena (near Jesenice) at Slovenia–Austria–Italy border. All these localities belong to the Southern Karavanka Mountains.

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Plate 2.1.

1,2. *Cordosphaeridium* cf. *spinosum* var. *deflandrei* (LEJ.-CARPENTIER 1941) DE CON. 1965, slide: Lepena-6-1, cross-table number: 11.9/144.6.

3,4. *Cordosphaeridium* cf. *tiara centrocarpum* (DEFL. and COOKS. 1955) MORG. 1966, slide: Lepena-6-1, cross-table number: 9.2/145.8.

5,6. *Glaphyrocysta* v. *Geridocysta* sp.1, slide: Lepena-6-1, cross-table number: 9.1/140.1.

7,8. *Glaphyrocysta* v. *Geridocysta* sp.2, slide: Lepena-6-1, cross-table number: 19.9/139.9.

9. *Leiotriletes dorogensis* (KDS. 1960) KDS. 1961 fvar. *triplan, Schizaeaceae, cf. Lygodium,* and *Cicatricosisporites dorogensis* R. POT. and GELL. 1933. subfsp. *dorogensis, Schizaeaceae, Anemia;* slide: Velenje Sv. Bric-3-1, cross table number: 5.4/133.5.

10. *Leiotriletes adriennis* (R. POT. and GELL. 1933) W. KR. 1959, *Schizaeaceae* cf. *Lygodium;* slide: Dobrna-2-1, 9.3/130.9.

11. *Leiotriletes microadriennis* W. KR. 1959, *Schizaeaceae* cf. *Lygodium;* slide: Dobrna-2-1, cross-table number: 5.6/144.1.

12. *Punctatisporites luteticus* W. KR. 1959; slide: Velenje Sv. Bric-4-2, cross-table number: 6.9/137.1.

13,14. *Toroisporis (Toroisporis) teuplitzenensis* W. KR. 1962 subfsp. *mediocris* W. KR. 1962. cf. *Gleicheniaceae,* slide: Dobrna-2-1, cross-table number: 23.2/147.2.

15. *Toroisporis (Toroisporis) guineti* KDS. 1973, cf. *Gleicheniaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 18.2/132.4.

16,17. *Concavisporites (Concavisporites) hungaricus* KDS. 1973, *Gleicheniaceae,* slide: Velenje Sv. Bric-4-2, cross-table number: 17.2/135.2.

18. Cf. *Echinatisporis longechinus* W. KR. 1959, *Selaginellaceae, Selaginella,* slide: Lepena-3-1, cross-table number: 13.5/135.6.

Plate 2.2.

1. *Punctatisporites luteticus* W. KR. 1959, with *Inaperturopollenites concedipites* (WODEH. 1933) W. KR. 1971, *Taxodiaceae-Cupressaceae,* slide: Velenje Sv. Bric-6-1, cross-table number: 11.4/129.6.

2. *Baculatisporites ovalis* KDS. 1973, *Osmundaceae,* slide: Dobrna-2-1, cross-table number: 24.8/134.3.

3. *Zlivisporis dorogensis* (KDS. 1965) PACLT. and SICS. 1970, *Lycopodiaceae, Lycopodium* v. *Selaginella,* Velenje Sv. Bric-4-2, cross-table number 22.3/129.6.

4,5. *Cicatricosisporites dorogensis* R. POT. and GELL. 1933 subfsp. *dorogensis, Schizaeaceae, Anemia,* slide: Dobrna-2-1, cross-table number: 10.2/142.3.

6,7. *Polypodiaceoisporites bauxitus* KDS. and J. RÁK. 1965, slide: Lepena-3-1, cross-table number: 20.8/146.7.

8. *Polypodiaceoisporites undulosculptatus* KDS 1973, *Pteridaceae,* slide: Velenje Sv. Bric-4-2, cross-table number: 6.5/147.9.

9,10. *Polypodiaceoisporites marxheimensis* (MÜRR. and PF. 1952) W. KR. 1959, *Pteridaceae,* slide: Velenje Sv. Bric-6-1, cross-table number: 9.5/137.2.

11,12. *Segmentizonosporites palaeogenicus* KDS. and J. RÁK. 1965, slide: Velenje Sv. Bric-4-1, cross-table number: 11.3/140.8.
13,14. *Trilites* fsp., slide: Velenje Sv. Bric-4-2, cross-table number: 12.7/146.2.
15. *Laevigatosporites haardti* (R. POT. and VEN. 1934) TH. and PF. 1953 subfsp. *haardti, Polypodiaceae,* slide: Dobrna-1-1, cross-table number: 8.6/132.1.
16,17. *Verrucatosporites favus* (R. POT. 1931) TH. and PF. 1953 subfsp. *favus, Polypodiaceae,* slide: Velenje Sv. Bric-6-1, cross-table number: 9.5/129.6.
18,19. *Alisporites* fsp. – reworked, slide: Socka-1-1, cross-table number: 7.7/144.8.
20,21. *Araucariacites balinkaense* KDS. 1974, *Araucariaceae,* slide: Dobrna-1-1, cross-table number: 8.9/130.8.
22,23. Cf. *Psophosphaera* fsp., *?Abietaceae, Pseudotsuga* v. *Larix,* slide: Dobrna-1-1, cross-table number: 4.8/140.3.
24,25. *Psophosphaera reissingeri* (KDS. 1961) KDS. 1974, slide: Velenje Sv. Bric-6-1, cross-table number: 5.2/142.6.
26,27. *Cupressacites dorogensis* (KDS. 1961) KDS. 1974, cf. *Coniferae,* slide: Lepena-8-1, cross-table number: 7.8/141.8.

Plate 2.3.

1,2. *Cycadopites kyushuensis* (TAKAHASHI 1961) KDS. 1968, *Ginkgoaceae,* v. *Cycadaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 7.8/130.6.
3,4. *Monocolpopollenites tranquillus* (R. POT. 1934) TH. and PF. 1953. subfsp. *tranquillus, Palmae,* slide: Velenje Sv. Bric-6-1, cross-table number: 17.2/151.3.
5,6. *Monocolpopollenites tranquillus* (R. POT. 1934) TH. PF. 1953 subfsp. *tranquillus, Palmae,* slide: Velenje Sv. Bric-6-1, cross-table number: 5.2/151.2.
7,8. *Spinizonocolpites* cf. *prominatus* (MCINTYRE 1965) KDS. 1974, *Palmae, Nipa,* slide: Lepena-3-1, cross-table number: 9.2/145.2.
9,10. *Spinizonocolpites* fsp., *Palmae,* cf. *Nipa,* slide: Lepena-2-1, cross-table number: 17.2/143.2.
11,12. *Spinizonocolpites* fsp., *Palmae,* cf. *Nipa,* slide: Lepena-3-1, cross-table number: 5.8/144.2.
13,14. *"Proxapertites africanus* KDS. nom. nud.", slide: Velenje Sv. Bric-3-1, cross-table number: 5.9/131.9.
15,16. Cf. *Ilexpollenites erdtmani* KDS. 1978, *Aquifoliaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 15.2/142.3.
17,18. *Intragranulitricolporites tumescens* (KDS. 1964) KDS. 1978, *Calyceraceae,* slide: Dobrna-1-1, cross-table number: 10.1/135.8.
19,20. *Fususpollenites fusus* (R. POT. 1934) KDS. 1978, *Fagaceae, Castanopsis,* slide: Dobrna-1-1, cross-table number: 8.9/139.8.
21,22. *Tetracolporopollenites urkuticus* KDS. 1978, *Sapotaceae,* slide: Dobrna-1-1, cross-table number: 8.1/140.1.
23,24. *Eocaenipollis* fsp., slide: Dobrna-1-1, cross-table number: 15.6/135.1.
25,26. *Pentapollenites laevigatus* W. KR. 1962 subfsp. *laevigatoides* W. KR. 1962, *Elaeagnaceae* v. *Simarubaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 16.3/144.4.
27,28. *Plicapollis pseudoexcelsus* (W. KR 1958) W. KR. 1961 subfsp. *turgidus* PF. 1953, cf. *Myricaceae,* slide: Dobrna-1-1, cross-table number: 8.9/127.6.
29,30. Cf. *Platycaryapollenites* fsp., *Juglandaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 7.2/135.9.
31,32. *Plicatopollis lunatus* KDS. 1974, *Juglandaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 8.6/130.1.
33,34. *Plicatopollis hungaricus* KDS. 1974, *Juglandaceae,* slide: Dobrna-1-1, cross-table number: 8.9/131.2.
35,36. *Plicatopollis krutzschi* KDS. 1974, *Juglandaceae,* slide: Velenje Sv. Bric-3-1, cross-table number: 9.3/143.8.
37,38. *Bombacacidites* fsp., *Bombacaceae,* slide: Lepena-3-1, cross-table number: 10.6/136.1.
39,40. *Compositoipollenites rhizophorus* (R. POT. 1934) R. POT. 1960 subfsp. *rhizophorus, Icacinaceae,* slide: Lepena-8-1, cross-table number: 10.2/133.1.

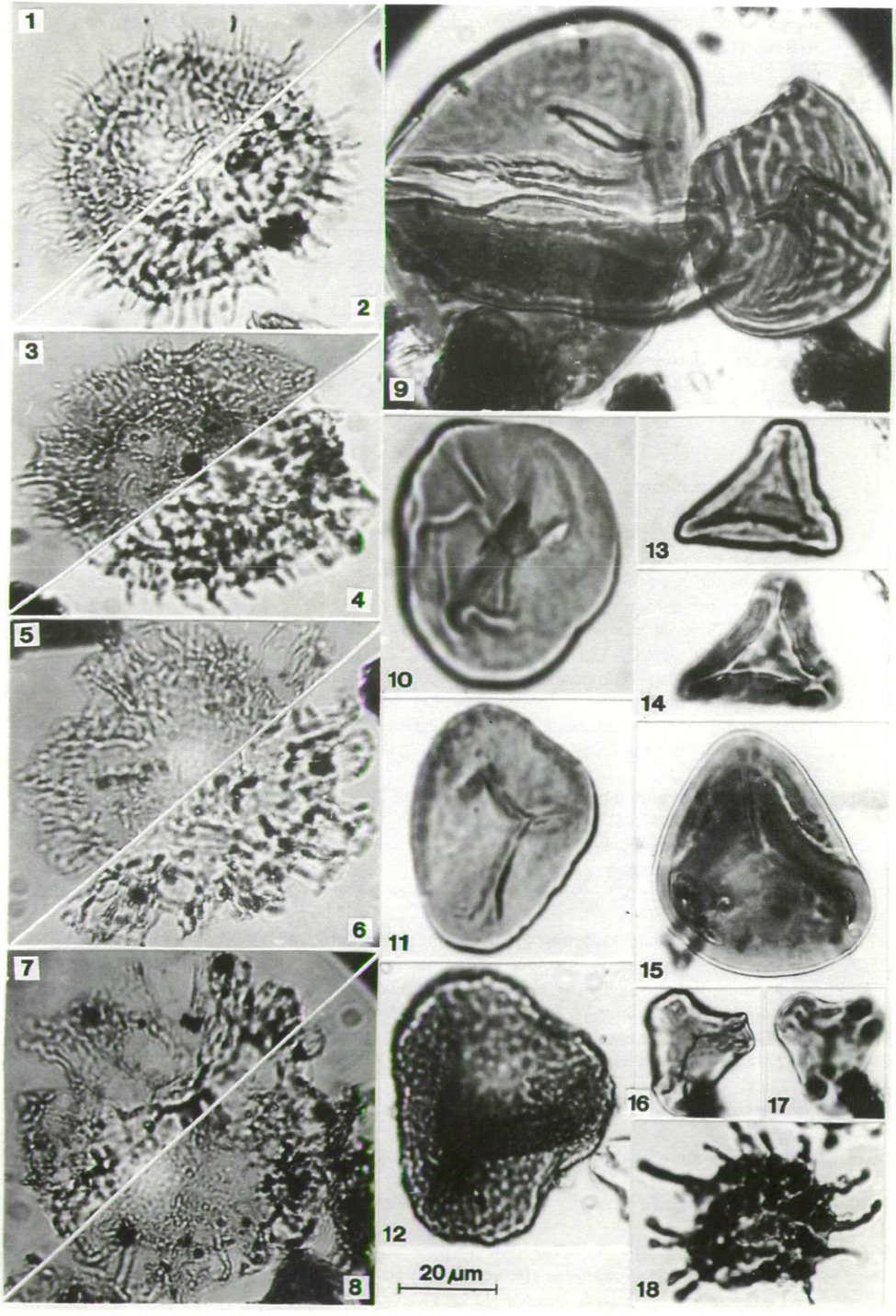

Plate 2.1.

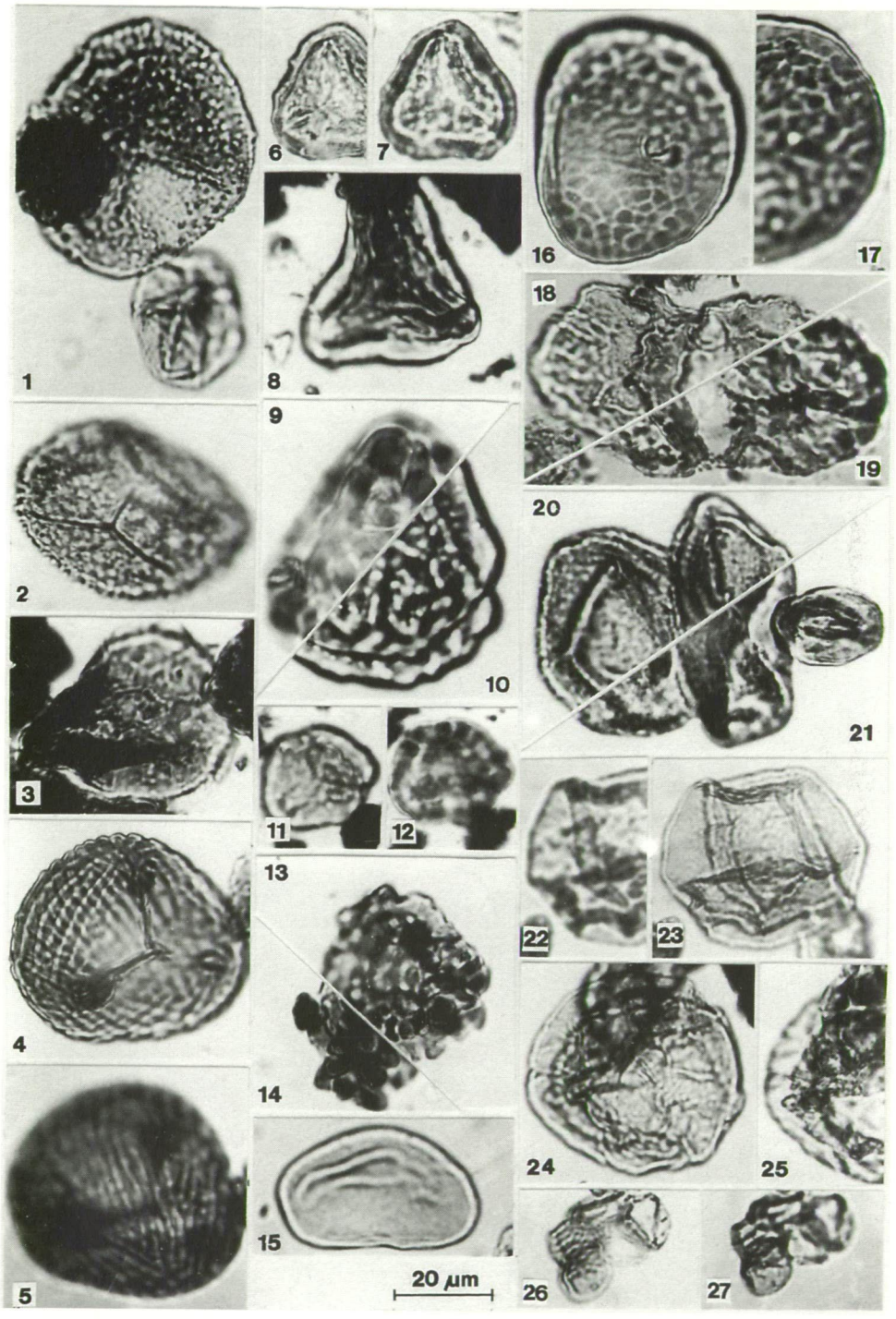

Plate 2.2.

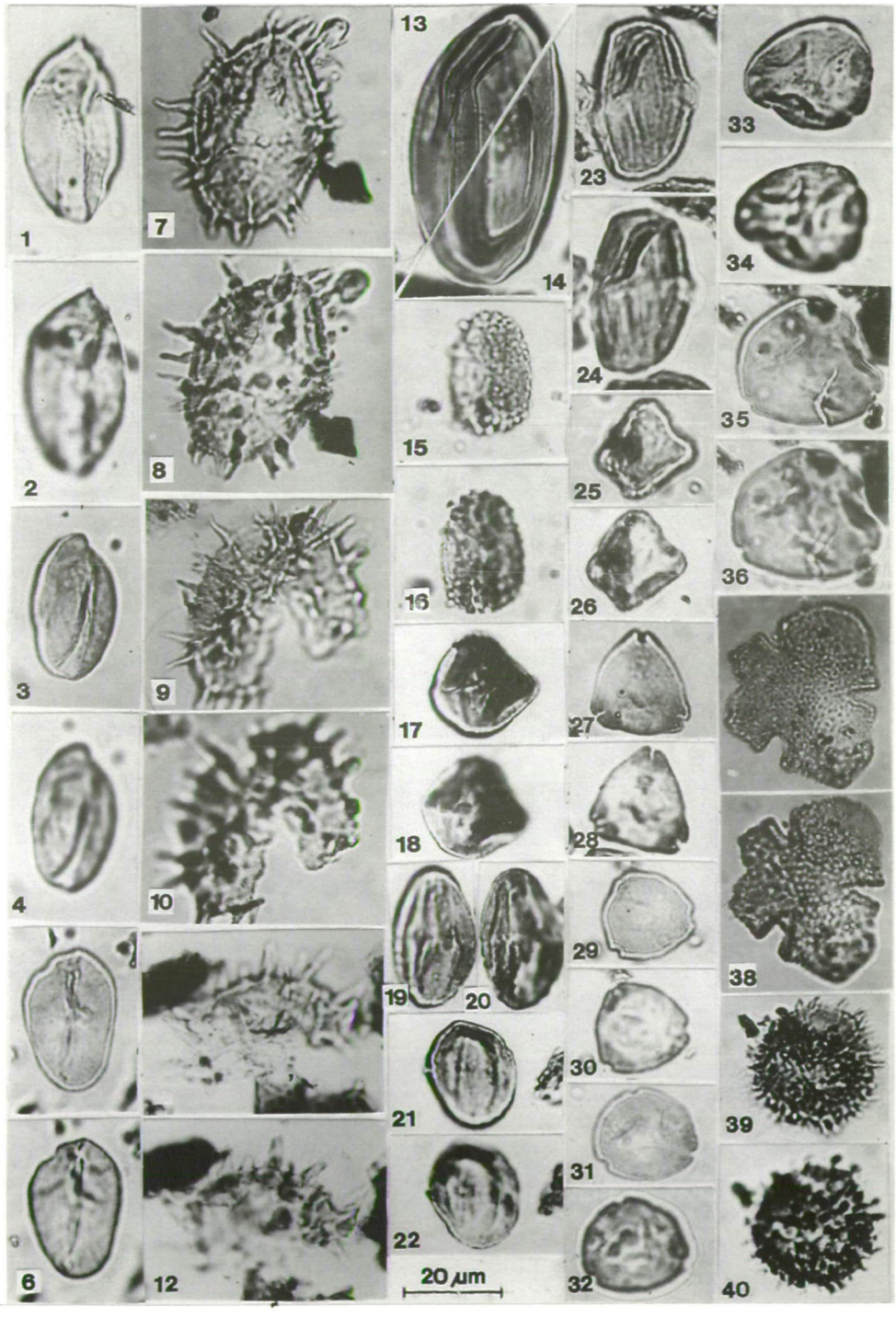
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Plate 2.3.

3. PLANT MICROFOSSILS FROM THE UPPER CRETACEOUS AND LOWER TERTIARY LAYERS OF NORTHERN SPAIN I.

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Abstract

The spore-pollen assemblages of two localities of the Upper Cretaceous layers from Northern Spain are presented in this contribution. In the sample of the Zambrana section (30 km South of Miranda de Ebro) the *gymnospermous Classoidites glandis* occurs in a dominant quantity with a large number of early *Brevaxonate* pollen grains: *Atlantopollis* and *Complexiopollis* fspp. This is similar to the spore-pollen assemblage isolated from Oviedo (SOLÉ DE PORTA, 1978) and to those of Fermetelos, Oia, etc. from Portugal (KEDVES and PÁRDUTZ, 1983). As for their geological age, the Lower Turonian seems to be probable. The spore-pollen assemblage of the Sobron section (80 km North-West of Burgos) is quite different. Dominant forms are the disaccate *gymnosperm* pollen grains. The quantity of the evolved early *Brevaxonate* pollen grains (*Eunormapolles: Papillopollis, Interporopollenites, Verruoculopollis, Endopollis, Krutzschipollis,* etc.) and that of the *Postnormapolles* is relatively large. A similar palynomorph assemblage was described from Guadalix (MÉDUS and ALVAREZ RAMIS, 1989), its geological age is probably Santonian.

Key words: Palynology, fossil, Upper Cretaceous, Spain.

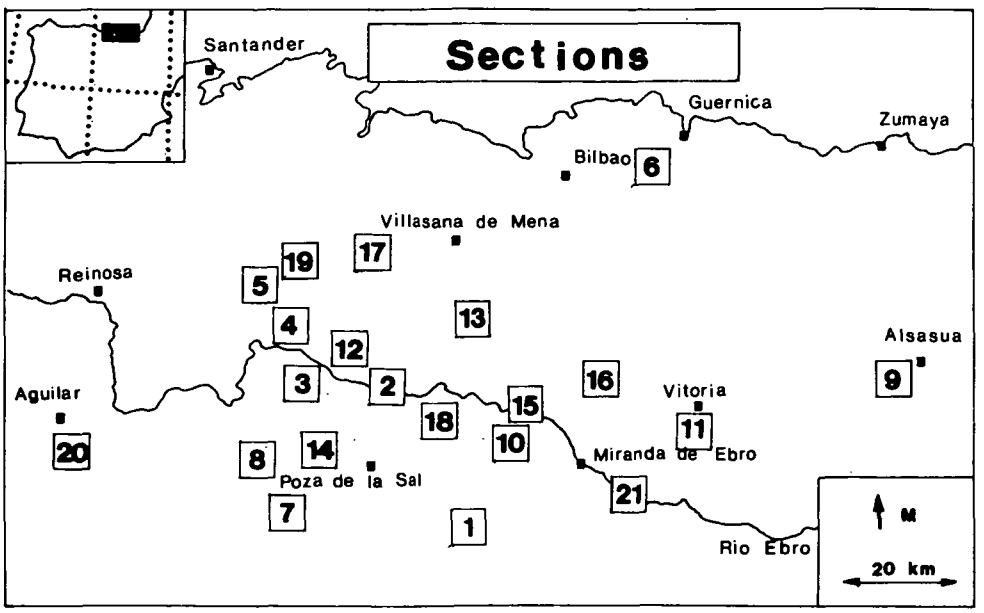
Introduction

There are several publications concerning the spore-pollen assemblages of the Upper Cretaceous sediments of Spain. On the basis of the different concepts of these researches the following, previously published papers may be mentioned:

1. Description of basic plant microfossil remains. AMEROM (1965, Cenomanian-Turonian of the Province of Léon, Northern Spain), SOLÉ DE PORTA (1978, Cenomanian from Los Alrededores de Oviedo), ALVAREZ RAMIS (1985, El Vellón, Madrid), PORTA, KEDVES, SOLÉ DE PORTA and CIVIS (1985, Maastrichtian of Barranco de La Posa, Lérida), ALVAREZ RAMIS, CLEMENTE BELMONTE, FERNÁNDEZ MARRÓN, GALÁN RUIZ and GÓMEZ PORTER (1987, El Vellón, Madrid), MÉDUS (1987, Campanian from Cedano, N. of Burgos), MÉDUS and ALVAREZ RAMIS (1989, Senonian from Guadalix of the Province of Madrid), ALVAREZ RAMIS and DOUBINGER (1980, Torrelaguna, Madrid).

2. Comparative investigations; Northern Spain with the Southern part of France; MÉDUS (1970a,b, 1972, 1975, 1978).

3. Paleophytogeography concerning the Mediterranean Region including the Iberian Peninsule: KRUTZSCH (1967, in: GÓCZÁN, GROOT, KRUTZSCH and PACLTOVÁ), KEDVES and DINIZ (1983), KEDVES (1985).
4. Investigation of the in situ pollen grains from Upper Cretaceous sediments of Spain; ALVAREZ RAMIS (1980, 1981), ALVAREZ RAMIS and FERNÁNDEZ MARRÓN (1986), ALVAREZ RAMIS, BARALE and FERNÁNDEZ MARRÓN (1987) BARALE, FERNÁNDEZ MARRÓN and ALVAREZ RAMIS (1988).



1 Bureba
2 Cereceda
3 Condado
4 Incinillas
5 Manzanedo
6 Marquina
7 Nidaguila
8 Nocedo
9 Olazagutia
10 Portilla
11 Puerto de Vitoria
12 Quecedo
13 Quintanilla la Ojada
14 Quintanaloma
15 Sobrón
16 Subijana
17 Torme
18 Trespaderne/Rio Oca
19 Tubilla/Rio Nela
20 Villaescusa de las Torres
21 Zambrana

Text-fig. 3.1.

Schematical map of the sampling localities following MARTINS.

Materials and Methods

Dr. ULRICH P. MARTINS (Department of Geology and Paleontology of the University of Tübingen, R. F. Germany) have sent me slides for palynological investigations. The materials of investigations may be divided into two groups. This paper deals with the spore-pollen assemblages of the lower two levels. On the basis of the letter of Dr. U. P. MARTINS dated on 3. 5. 1987, the data of the marlstone samples are the following.
Sample 194/10 (2 slides) came from the Sobron Section, 80 km North-West of Burgos, approximately Lower Santonian in age.
Sample 268/14 (4 slides) originates from the Zambrana Section, 30 km South of Miranda de Ebro, same age. The treatment of the samples started with HNO_3 (65%).

The localities of the sampling by Dr. U. P. MARTINS are illustrated on text-fig. 3.1. (cf. MARTINS 1988, 1989). The stratigraphic column of Quintanilla la Ojada – Losa Valley – (Text-fig. 3.2.) illustrates the stratigraphic situations of the samples under palynological investigation. On the basis of the preliminary studies, the two levels presented in this contribution represents the oldest part of the Upper Cretaceous in this region. For the first step the spore-pollen assemblages are elaborated, the *Acritarchs* will be the subjects of further investigations.

Results

1. ZAMBRANA SECTION (30 KM SOUTH OF MIRANDA DE EBRO)
No: 268/14

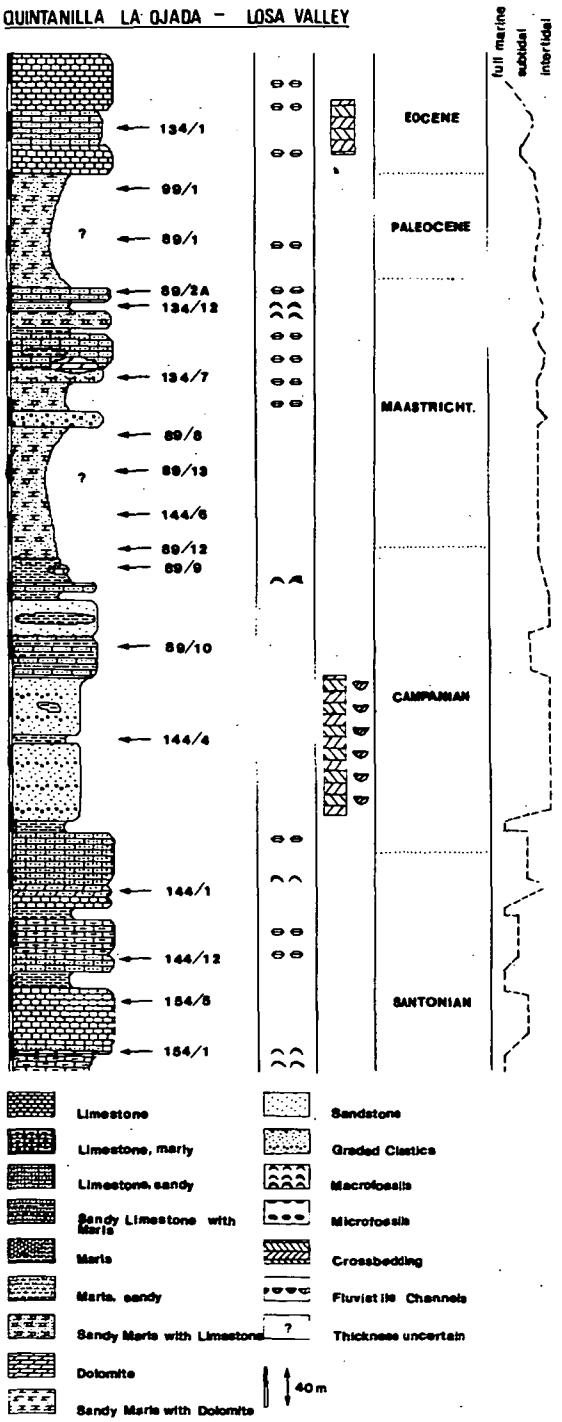
Quantitative data

	No of specimens
Hystrichosphaeridae	196
Sporites	7
Disaccites	8
Classoidites	57
Atlantopollis	43
Complexiopollis	17

Qualitative data

Sporites

Stereisporites aegypticus KEDVES 1986, *Sphagnaceae* (Plate 3.1., figs. 1,2),
Ischiosporites cf. *tuberosus* DÖRING 1965 (Plate 3.1., figs. 10,11),
Ischiosporites cf. *pseudoreticulatus* (COUPER 1958) DÖRING 1965 (Plate 3.1., fig. 12),
Cicatricosisporites baconicus H. DEÁK 1963, *Schizaeaceae* (Plate 3.1., fig. 3),
Appendicisporites potomacensis BRENNER 1963, *Schizaeaceae* (Plate 3.1., fig. 4),
Cf. *Clavatisporites* fsp. (Plate 3.1., fig. 5),



◂ Text-fig. 3.2.

Stratigraphical column of Quintanilla La Ojada – Losa Valley and the position of the samples which are the subjects of this research program. Schema following MARTINS.

Liburnisporites fsp. (Plate 3.1., figs. 6,7),
Uvaesporites cf. *neerlandicus* HERNGREEN, FELDER, KEDVES and MEESSEN 1986 (Plate 3.1., fig. 13),
Camarozonosporites insignis NORRIS 1967, *Lycopodiaceae* (Plate 3.1., figs. 8,9).

Pollenites

Podocarpidites multesimus (BOLKHOVITINA 1956) POCOCK 1962 (Plate 3.1., figs. 14,15),
Classoidites glandis AMEROM 1965 (Plate 3.1., figs. 16,17),
Atlantopollis microreticulatus KRUTZSCH 1967 (Plate 3.1., figs. 18,19),
Atlantopollis vilaflorensis KEDVES and DINIZ 1979 (Plate 3.1., figs. 20,21),
Atlantopollis grooti KEDVES and DINIZ 1979 (Plate 3.1., figs. 22,23),
Atlantopollis choffatii DINIZ, KEDVES and SIMONCSICS 1974 (Plate 3.1., fig. 24),
Complexiopollis praeatumescens KRUTZSCH 1959 (Plate 3.1., figs. 25–28),
Complexiopollis vulgaris (GROOT and GROOT 1962) GROOT and KRUTZSCH 1967 (Plate 3.1., figs. 29,30),
Complexiopollis subtilis (KRUTZSCH 1959) KRUTZSCH 1967 (Plate 3.1., figs. 31,32),
Complexiopollis latis (KRUTZSCH 1959) KRUTZSCH 1967 (Plate 3.1., figs. 33,34).

2. SOBRON SECTION (80 KM. NORTH-WEST OF BURGOS)
No: 194/10

Quantitative data

	No of specimens
Hystrichosphaeridae	124
Dissaccites	89
Classoidites	2
Longaxones	3
Eunormapolles	52
Postnormapolles	6

Qualitative data

Pollenites

Pinuspollenites spherisaccus BRENNER 1963 (Plate 3.2., figs. 1,2),
Podocarpidites verruculatus (TREVISAN 1967) KRUTZSCH 1971 (Plate 3.2., figs. 3,4),
Retitricolpites minutus (BRENNER 1963) DETTMANN 1973 (Plate 3.2., figs. 5,6),
Ilexpollenites erdtmani KEDVES 1978, *Aquifoliaceae* (Plate 3.2., figs. 7,8),
Complexiopollis cf. *patulus* TSCHUDY 1973 (Plate 3.3., figs. 31,32),
Verruoculopollis fsp. (Plate 3.2., figs. 9,10),
Endopollis fsp. (Plate 3.2., figs. 11,12),
Krutzschipollis spatiosus GÓCZÁN (Plate 3.2., figs. 13,14),

Semioculopollis medius KEDVES and DINIZ 1983 (Plate 3.2., figs. 15,16),
Papillopollis fsp. (Plate 3.2., figs. 17,18),
Papillopollis pflugii KEDVES and PITTAU 1979 (Plate 3.3., figs. 1,2),
Papillopollis vancampoae KEDVES and PITTAU 1979 (Plate 3.3., figs. 3–6),
Papillopollis rugulatus KEDVES and PITTAU 1979 (Plate 3.3., figs. 7,8),
Papillopollis regulus PFLUG 1953 (Plate 3.3., figs. 9,10),
Rocheipollenites triangulus KEDVES and DINIZ 1980 (Plate 3.3., figs. 11,12),
Triangulipollis cf. *magnus* KEDVES and DINIZ 1980–1981 (Plate 3.3., figs. 15,16),
Interporopollenites plicatus KEDVES and HEGEDÜS 1975 (Plate 3.3., figs. 13,14,17,18),
Interporopollenites stanley KEDVES and HEGEDÜS 1975 (Plate 3.3., figs. 19,20),
Interporopollenites concavus KEDVES and HEGEDÜS 1975 (Plate 3.3., figs. 21,22),
Interporopollenites dinizae KEDVES and HEGEDÜS 1975 (Plate 3.3., figs. 23,24),
Interporopollenites ornatus KEDVES and HEGEDÜS 1975 (Plate 3.3., figs. 25,26),
Alnipollenites fsp. (Plate 3.3., figs. 27,28),
Triporopollenites nointelensis KEDVES 1970, *Corylaceae*, (Plate 3.3., figs. 29,30),
Triatriopollenites lubomirovae (GLADKOVA 1965) KEDVES 1974, *Myricaceae* (Plate 3.3., figs. 31,32),
Inaperturopollenites lacunosus VAN HOEKEN-KLINKENBERG 1964 (Plate 3.3., figs. 33,34).

Discussion and Conclusions

1. The large quantity of the planctonic organisms in both assemblages need further investigations in the future.
2. The spore-pollen assemblage of the Zambrana section is a very good basis of comparison for the lower part of the Upper Cretaceous spore-pollen assemblages in Northern Spain. This can be characterized with the early *Normapolles* genera, *Atlantopollis* and *Complexiopollis*. The lack of the *Probrevaxones*, and the fact, that during my investigation *Longaxones* pollen grains were not observed is worth mentioning. Obviously, further investigations will probably enrich our knowledge of this matter. This assemblage may be compared to further European localities in the boreal region, too; cf. KRUTZSCH 1967, in GÓCZÁN, GROOT, KRUTZSCH and PACLTOVÁ.
3. The spore-pollen assemblage of the Sobron locality is much younger, with no intermediate assemblages till this time. This is similar to the Upper Cretaceous spore-pollen assemblages from Portugal. Until this time we have been able to use the so-called Aveiro type from Portugal for comparison, but further investigations are necessary needed.

Acknowledgements

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Plate 3.1.

1,2. *Stereisporites aegypticus* KEDVES 1986, *Sphagnaceae,* slide: 268/14-1, cross-table number: 8.8/135.3.
3. *Cicatricosisporites baconicus* H. DEÁK 1963, *Schizaeaceae,* slide: 268/14-4, cross-table number: 10.5/135.8.
4. *Appendicisporites potomacensis* BRENNER 1963, *Schizaeaceae,* slide: 268/14-3, cross-table number: 10.3/138.8.
5. Cf. *Clavatisporites* fsp., slide: 268/14-3, cross-table number: 26.2/130.1.
6,7. *Liburnisporites* fsp., slide: 268/14-1, cross-table number: 8.4/131.6.
8,9. *Camarozonosporites insignis* NORRIS 1967, *Lycopodiaceae,* slide: 268/14-3, cross-table number: 10.9/143.6.
10,11. *Ischiosporites* fsp. cf. *tuberosus* DÖRING 1965, slide: 268/14-2, cross-table number: 6.5/127.6.
12. *Ischiosporites* cf. *pseudoreticulatus* (COUPER 1958) DÖRING 1965, slide: 268/14-1, cross-table number: 13.4/127.4.
13. *Uvaesporites* cf. *neerlandicus* HERNGREEN, FELDER, KEDVES and MEESSEN 1986, slide: 268/14-4, cross-table number: 11.5/134.8.
14,15. *Podocarpidites multesimus* (BOLKHOVITINA 1956) POCOCK 1962, slide: 268/14-3, cross-table number: 8.6/130.6.
16,17. *Classoidites glandis* AMEROM 1965, slide: 268/14-3, cross-table number: 8.3/129.4.
18,19. *Atlantopollis microreticulatus* KRUTZSCH 1967, slide: 268/14-3, cross-table number: 8.3/129.4.
20,21. *Atlantopollis vilaflorensis* KEDVES and DINIZ 1979, slide: 268/14-2, cross-table number: 24.2/131.8.
22,23. *Atlantopollis grooti* KEDVES and DINIZ 1979, slide: 268/14-1, cross-table number: 15.6/141.7.
24. *Atlantopollis choffatii* DINIZ, KEDVES and SIMONCSICS 1974, slide: 268/14-1, cross-table number: 7.4/137.2.
25,26. *Complexiopollis praeatumescens* KRUTZSCH 1959, slide: 268/14-3, cross-table number: 9.8/139.1.
27,28. *Complexiopollis praeatumescens* KRUTZSCH 1959, slide: 268/14-4, cross-table number: 17.3/127.4.
29,30. *Complexiopollis vulgaris* (GROOT and GROOT 1962) GROOT and KRUTZSCH 1967, slide: 268/14-1, cross-table number: 20.4/143.8.
31,32. *Complexiopollis turonis* (KRUTZSCH 1959) KRUTZSCH 1967, slide: 268/14-2, cross-table number: 20.2/121.8.
33,34. *Complexiopollis latis* (KRUTZSCH 1959) KRUTZSCH 1967, slide: 268/14-1, cross-table number: 21.3/128.9.

Plate 3.2.

1,2. *Pinuspollenites spherisaccus* BRENNER 1963, slide: 194/10-2, cross-table number: 6.7/127.1.
3,4. *Podocarpidites verrucatulus* (TREVISAN 1967) KRUTZSCH 1971, *Podocarpaceae,* slide: 194/10-1, cross-table number: 10.3/135.3.
5,6. *Retitricolpites minutus* (BRENNER 1963) DETTMANN 1973, slide: 194/10-1, cross-table number: 19.9/130.3.
7,8. *Ilexpollenites erdtmani* KEDVES 1978, *Aquifoliaceae,* slide: 194/10-1, cross-table number: 6.8/138.7.
9,10. *Verruoculopollis* fsp., slide: 194/10-1, cross-table number: 8.3/130.7.
11,12. *Endopollis* fsp., slide: 194/10-2, cross-table number: 20.2/125.9.

13,14. *Krutzschipollis spatiosus* GÓCZÁN 1967, slide: 194/10-1, cross-table number: 11.2/127.4.
15,16. *Semioculopollis medius* KEDVES and DINIZ 1983, slide: 194/10-1, cross-table number: 10.3/130.3.
17,18. *Papillopollis* fsp., slide: 194/10-2, cross-table number: 18.2/127.2.

Plate 3.3.

1,2. *Papillopollis pflugii* KEDVES and PITTAU 1979, slide: 194/10-2, cross-table number: 12.9/129.3.
3,4. *Papillopollis vancampoae* KEDVES and PITTAU 1979, slide: 194/10-2, cross-table number: 22.2/140.8.
5,6. *Papillopollis vancampoae* KEDVES and PITTAU 1979, slide: 194/10-1, cross-table number: 18.4/135.2.
7,8. *Papillopollis rugulatus* KEDVES and PITTAU 1979, slide: 194/10-1, cross-table number: 6.8/136.9.
9,10. *Papillopollis regulus* PFLUG 1953, slide: 194/10-1, cross-table number: 17.7/130.9.
11,12. *Rocheipollenites triangulus* KEDVES and DINIZ 1980, slide: 194/10-2, cross-table number: 9.3/131.6.
13,14. *Interporopollenites plicatus* KEDVES and HEGEDÜS 1975, slide: 194/10-2, cross-table number: 21.2/128.9.
15,16. *Triangulipollis* cf. *magnus* KEDVES and DINIZ 1980–1981, slide: 194/10-2, cross-table number: 8.3/129.9.
17,18. *Interporopollenites plicatus* KEDVES and HEGEDÜS 1975, slide: 194/10-1, cross-table number: 9.2/129.3.
19,20. *Interporopollenites stanley* KEDVES and HEGEDÜS 1975, slide: 194/10-1, cross-table number: 20.8/136.5.
21,22. *Interporopollenites concavus* KEDVES and HEGEDÜS 1975, slide: 194/10-2, cross-table number: 24.3/123.4.
23,24. *Interporopollenites dinizae* KEDVES and HEGEDÜS 1975, slide: 194/10-1, cross-table number: 16.3/140.6.
25,26. *Interporopollenites ornatus* KEDVES and HEGEDÜS 1975, slide: 194/10-2, cross-table number: 22.3/134.2.
27,28. *Alnipollenites* fsp., slide: 194/10-1, cross-table number: 16.5/142.2.
29,30. *Triporopollenites nointelensis* KEDVES 1970, *Corylaceae,* slide: 194/10-1, cross-table number: 12.2/136.1.
31,32. *Triatrioporopollenites lubomirovae* (GLADKOVA 1965) KEDVES 1974, *Myricaceae,*, slide: 194/10-2, cross-table number: 9.9/136.9.
* *Complexiopollis* cf. *patulus* TSCHUDY 1973.
33,34. *Inaperturotetradites lacunosus* VAN HOEKEN-KLINKENBERG 1964, slide: 194/10-2, cross-table number: 17.6/141.6.

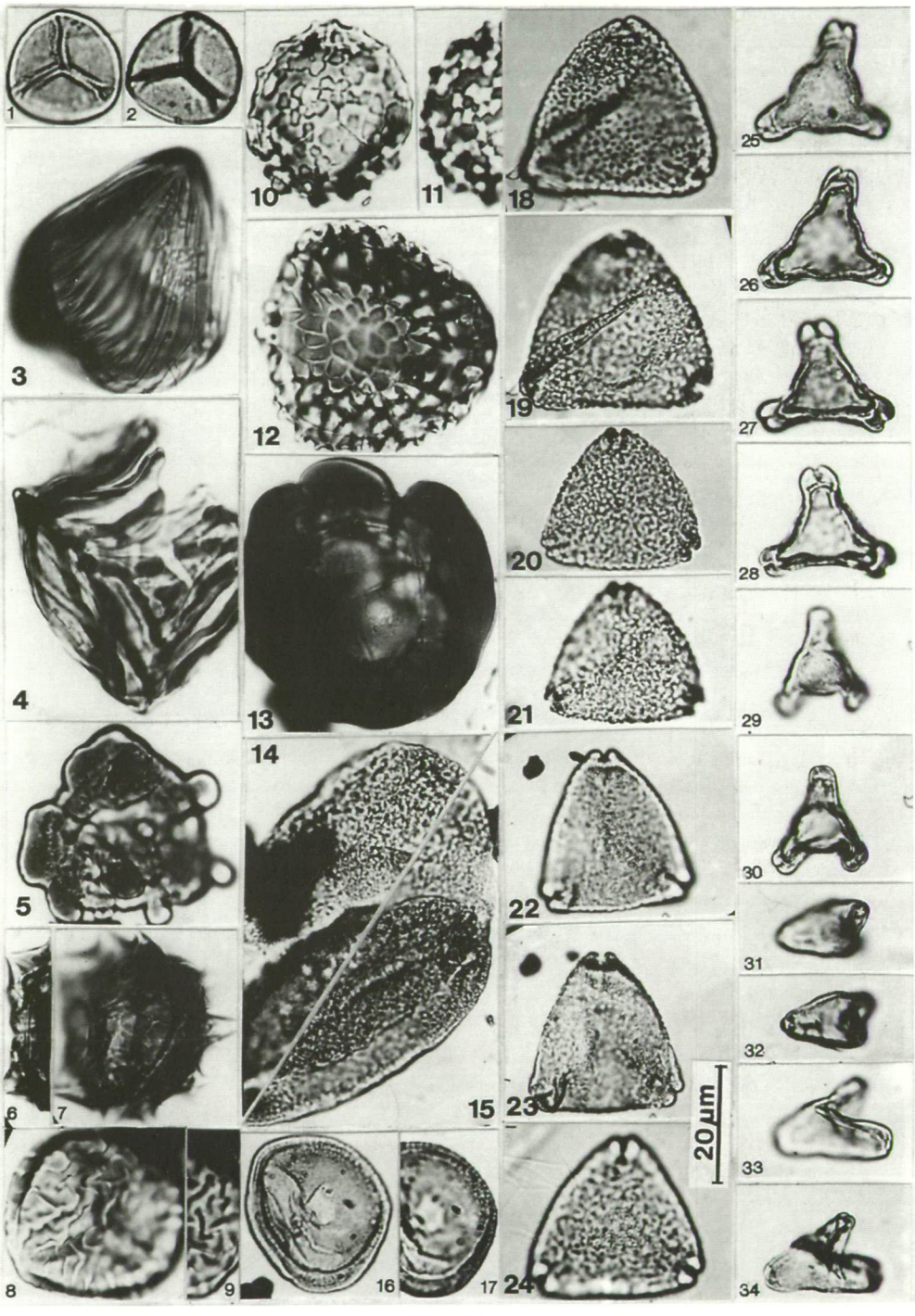
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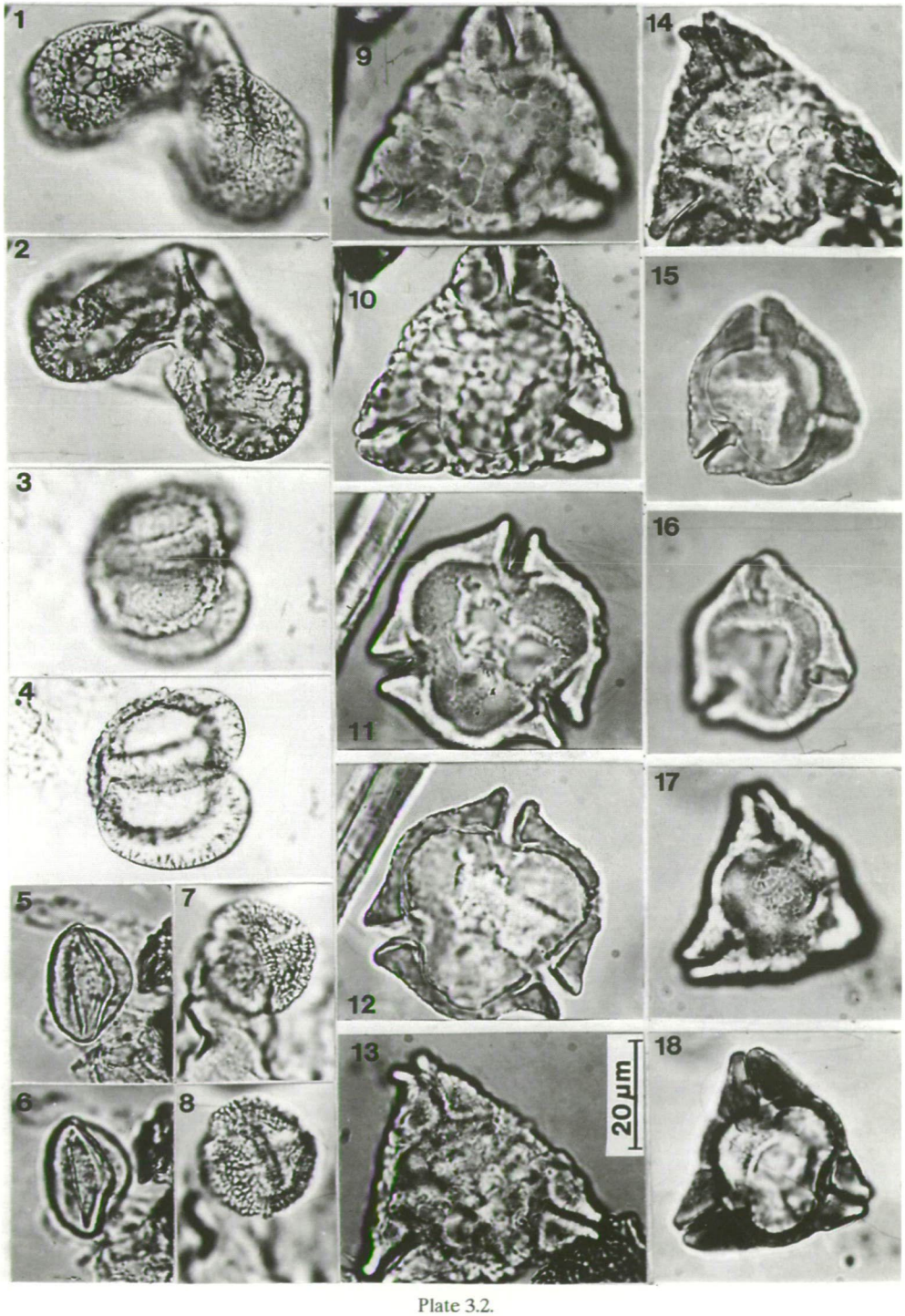
Plate 3.1.



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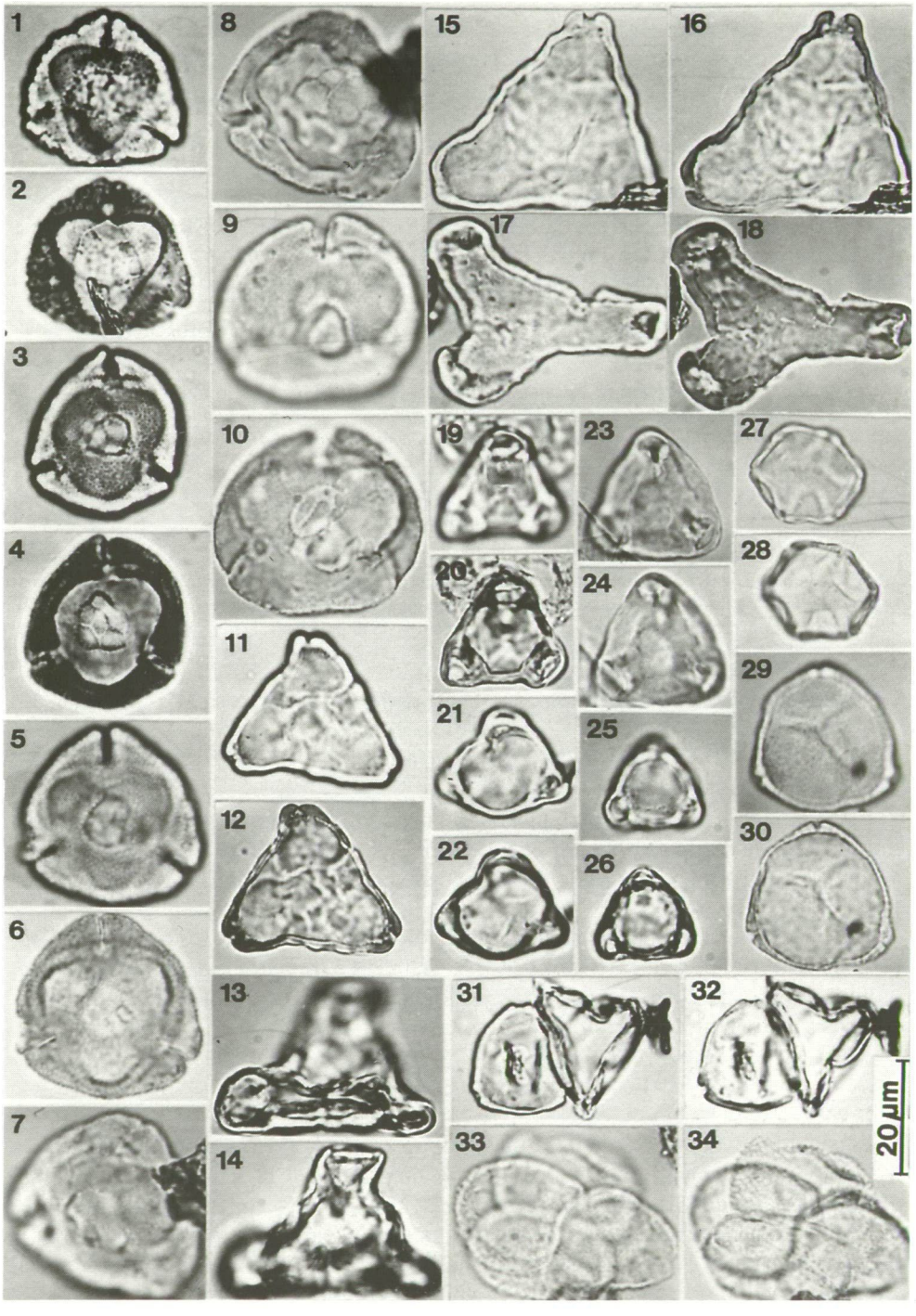
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Plate 3.3.

4. CONSIDERACIONES EN TORNO A LAS ASOCIACIONES ESPOROPOLINICAS DEL CRETACICO SUPERIOR DEL CERRO DE LA MESA (GUADALIX DE LA SIERRA, MADRID)

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Resumen

Se discuten los resultados obtenidos del estudio paleopalinológico efectuado en 7 niveles, tomados a lo largo de una serie litoestratigráfica establecida en sedimentos cretácicos de la provincia de Madrid. Se determinan los porcentajes de los principales componentes de la paleoasociación y se comparan con los de otros yacimientos cretácicos, más o menos sincrónicos

Palabras clave: Palinología, fósil, Cretácico superior, provincia de Madrid, España.

Introducción

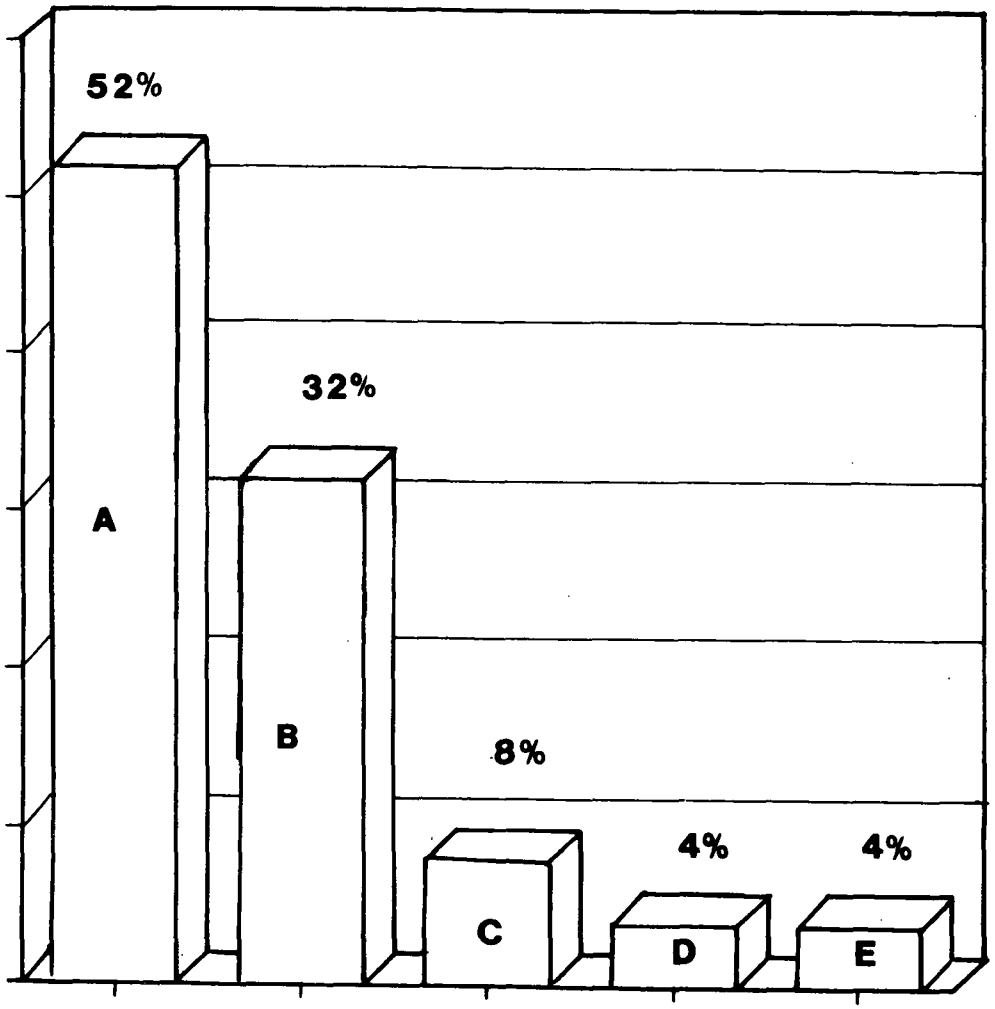
Este estudio forma parte de una serie de proyectos que nos han sido concedidos ininterrumpidamente por el CSIC y la DGCYT desde 1982 hasta 1995 entre los que se incluye un proyecto concedido por la comisión mixta Hispano-Hungara para 1992 y 1993.

Las muestras estudiadas se han tomado en diferentes puntos de los tramos 4 y 6 de la serie estratigráfica local figs. 4.2., 4.3., 4.4. y 4.5. siendo todas ellas ricas en palinomorfos (cutículas, leños, algas, esporas y sobre todo pólenes) además de algunas cámaras internas de *Foraminíferos.*

Localización y acceso al yacimiento

El yacimiento del Cerro de la Mesa se encuentra en la Comunidad Autónoma de Madrid. Geográficamente se situa en el borde meridional de la Sierra de Guadarrama que forma parte del Sistema Central.

Los materiales estudiados proceden de una explotación, a cielo abierto, de la que se extraen bloques de caliza compacta empleados en la construcción. La cantera se situa en un cerro de cima plana, mesa, ubicado en una zona próxima al pueblo de Guadalix de la Sierra.



A ANGIOSPERMAS PRIMITIVAS

B GIMNOSPERMAS

C ESPORAS

D ANGIOSPERMAS TIPO ACTUAL

E OTROS

Figura 4.1.

El emplazamiento preciso de la columna establecida en el Cerro de la Mesa corresponde a las coordenadas (Greenwich) 40° 47' 37" N y 3° 42' 05" W.

El acceso al yacimiento, desde la ciudad de Madrid, se efectua a través de la Carretera Nacional I hasta el kilómetro 50 en que ésta se cruza, casi perpendicularmente, con las carreteras que conducen a Torrelaguna (por el Este) y a Guadalix de la Sierra (por el Oeste). Siguiendo por esta última se llega al pueblo de Guadalix de la Sierra, donde se toma, en dirección Norte, otra carretera que conduce a Navalafuente; de ella parte el camino que da servicio a varias explotaciones ganaderas y que conduce a la cantera del Cerro de la Mesa.

Aspectos geológicos

La zona en que se emplaza el yacimiento forma parte del Sistema Central y se situa en el borde meridional de la Sierra de Guadarrama. Los materiales cretácicos, junto con los paléogenos rellenan una cubeta que se dispone en dirección SW-NE formando la cobertera de la Sierra de Guadarrama (ALVAREZ-RAMIS, FERNÁNDEZ MARRÓN y GOMEZ PORTER, 1984, CORCHON RODRIGUEZ, 1976 y FUSTER y FEBREL, 1959). En la zona en que se situa el yacimiento el Cretácico forma un sinclinal que cierra periclinalmente en dirección al pueblo de Guadalix de la Sierra y cuyo eje se encuentra más próximo al flanco norte. El Cerro de la Mesa se situa en el flanco sur del Sinclinal; los materiales cretácicos que integran sus capas presentan un buzamiento de 45°N. Los materiales que constituyen los niveles cretácicos estan formados fundamentalmente por calizas (que en algunas capas pueden presentar elevados porcentajes de margas o arenas) y otros niveles de arcillas de escasa potencia. La disposición de los materiales se caracteriza por presentar una alternacia cíclica. La sucessión litológica, de donde proceden las muestras, es la característica de todas las canteras situadas en el Borde Sur de la Sierra de Guadarrama. La serie local establecida, está formada por calizas más o menos compactas (algunas con porcentajes elevados de arena) y margas. De forma discontinua aparecen intercalados pequenos niveles carbonosos (figuras 4.2., 4.3., 4.4. y 4.5.). La columna forma parte de una de las unidades litoestratigráficas establecidas por CORCHON RODRIGUEZ en 1976.

Caracterización palinológica del Cretácico superior del Borde Sur de la Sierra de Guadarrama

La inclusión en este artículo de este apartado se justifica en base a que para hacer una caracterización fiable de paleobioasociaciones, es necesario conocer previamente las caracteristicas de otros yacimientos de la misma edad, o de niveles próximos, enclavados en el área en que se localiza el yacimiento. Esta circunstancia se cumple en este caso, ya que en el Cretácico superior del borde meridional de la Sierra de Guadarrama se han estudiado otros yacimientos, la mayoria de ellos en profundidad. Al haberse iniciado, en el último año, el reconocimiento de tres nuevos yacimientos, nos hace variar ligeramente los porcentajes del conjuncto de los distintos grupos sistemáticos dados a conocer en el 8° Simposio de Palinologia (ALVAREZ RAMIS, y FERNÁNDEZ MARRÓN, 1990). No hemos estimado necessario dar a conocer aisla-

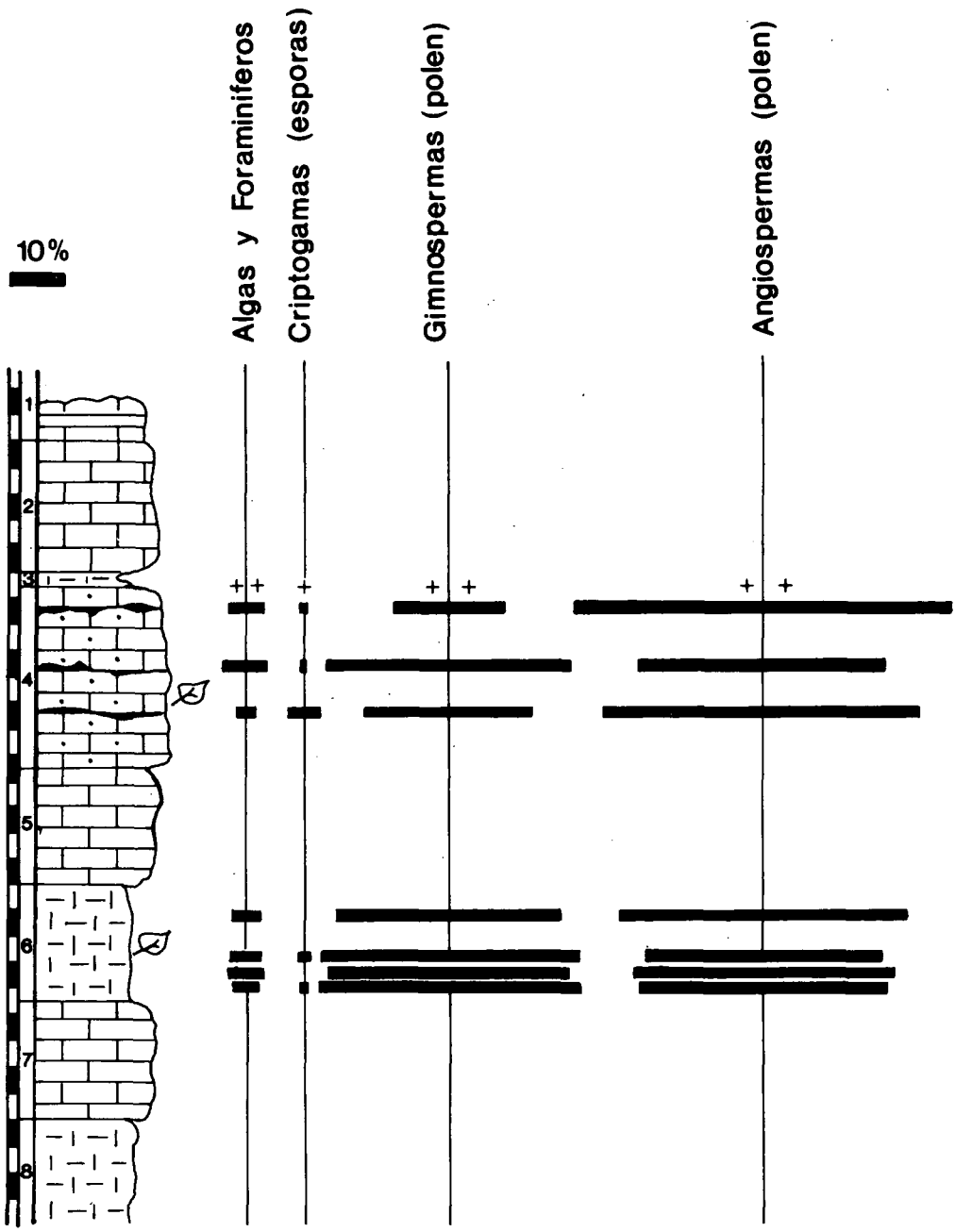

10%
Algas y Foraminíferos
Criptogamas (esporas)
Gimnospermas (polen)
Angiospermas (polen)
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Figura 4.2.

damente los porcentajes de cada nivel ya que aunque las preparaciones pueden presentar entre si marcadas diferencias, sus promedios son muy semejantes tanto en porcentajes como en tipos botánicos. Los grupos establecidos fueron: Esporas, pólenes de *Gimnospermas,* pólenes de *Angiospermas* primitivas, pólenes de *Angiospermas* de tipo actual y otros. Este apartado carece de rigor paleobiológico, al incluir representantes del reino *Proctista (Dinoflagelados, Botryococcales)*, epidermis vegetales, vasos conductores, etc. junto a epidermis de animales, cámaras internas de *Foraminiferos* etc. Seguidamente indicamos, en porcentajes, los componentes comunes que hemos establecido en todos los yacimientos estudiados (figura 4.1.).

Aspectos paleopalinológicos del Cerro de la Mesa

En 1990 ALVAREZ RAMIS y FERNÁNDEZ MARRÓN dimos a conocer el estudio palinológico preliminar de este yacimiento, indicando el promedio de los distintos porcentajes obtenidos en los diversos niveles de la serie establecida. La metodología empleada en la obtención de los palinomorfos fué la citada en publicaciones anteriores por los autores para los grana incluidos en niveles de carbones y margas. En la continuación de ese estudio, que damos a conocer aquí, se han mantenido en principio los mismos grupos básicos establecidos, si bien a la vista de los resultados que se iban obteniendo se profundizó en el conocimiento de las *Angiospermas* por su importancia e interés en aspectos tales como la filogenia, evolución, areas de dispersión y valor estratigráfico de estas plantas durante el Cretácico superior. No pormenorizamos los distintos géneros sistemáticos obtenidos en el estudio de las paleoasociaciones del yacimiento aunque se han reconocido nuevas formas de *Dinoquistes* y sobre todo de *Normapólenes* que constituyen el objetivo básico de esta publicación. Los valores que arrojan los nuevos porcentajes obtenidos se desvian poco de los que habíamos obtenido previamente, siendo los más significativos el aumento de las *Gimnospermas* (5%) y la disminución de las *Criptógamas* (4%). Detallando los porcentajes determinados en los siete niveles en que se ha realizado el muestro los resultados obtenidos ponen de manifesto que las *Angiospermas* son dominantes en todos ellos, seguidos muy se cerca por los pólenes de *Gimnospermas,* siendo casi idénticos en el tramo 6.

Estos porcentajes se expresan gráficamente a la derecha de la serie local establecida (figura 4.2.).

En otra figura puede apreciarse la distribución en la serie de los porcentajes hallados para los tipos polínicos más representativos de *Coníferas* (figura 4.3.). Los porcentajes y distribución obtenidos para el Cerro de la Mesa no son concordantes con los obtenidos en yacimientos sincrónicos estudiados en la zona. (ALVAREZ RAMIS 1985, ALVAREZ RAMIS y GOMEZ PORTER, 1985 y ALVAREZ RAMIS y FERNÁNDEZ MARRÓN 1990).

La siguiente figura (figura 4.4.) se refiere a las *Angiospermas,* indicando los porcentajes obtenidos para los distintos niveles en que se han estudiado los palinomorfos. En el centro de la figura se representan los porcentajes de *Angiospermas* cuyo eje polar supera al eje ecuatorial. Este tipo lo presentan con mayor frecuencia las *Angiospermas* actuales. A la derecha de la figura se representan los pólenes *Breviejes*

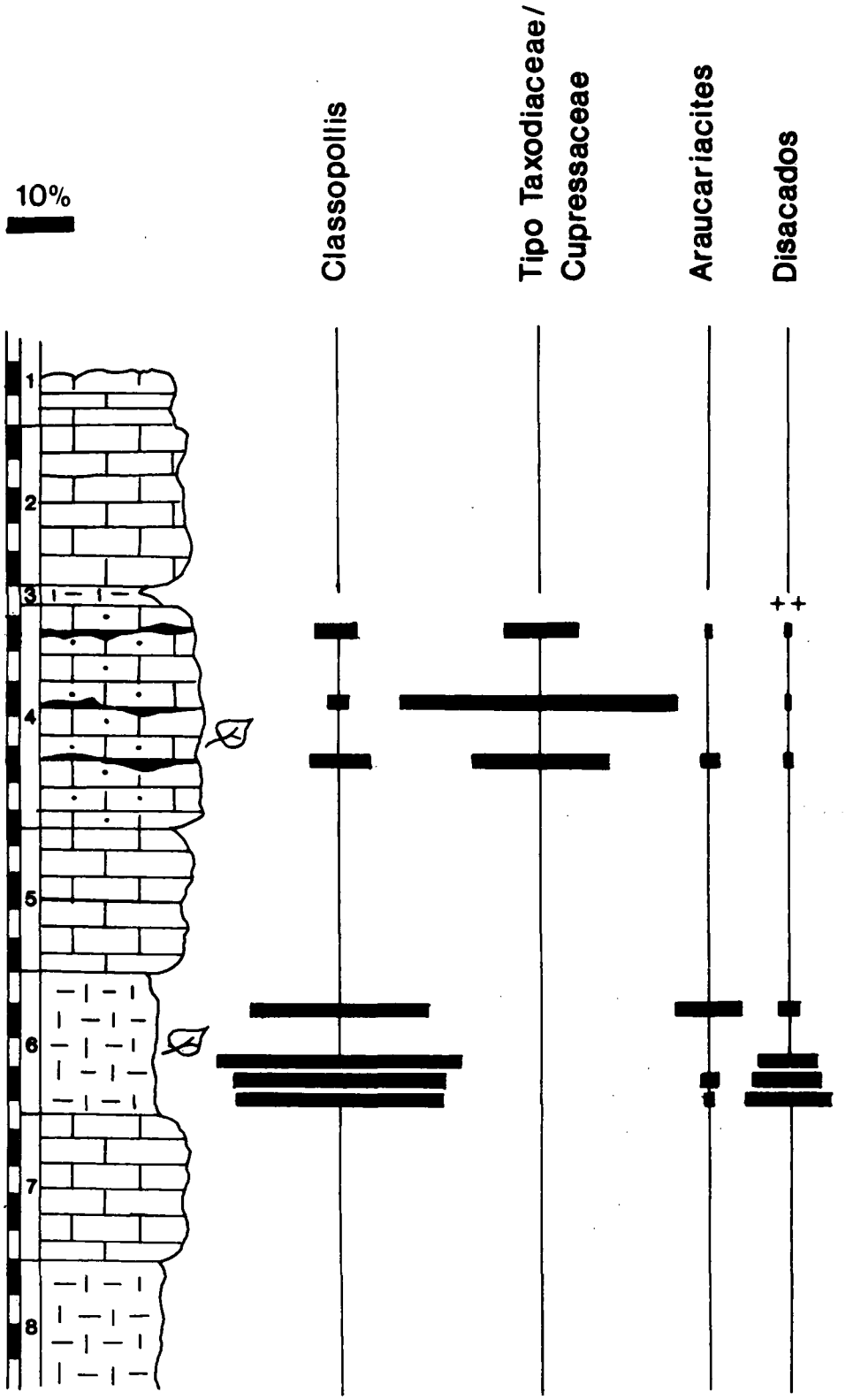
10%
Classopollis
Tipo Taxodiaceae/
Cupressaceae
Araucariacites
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Figura 4.3.

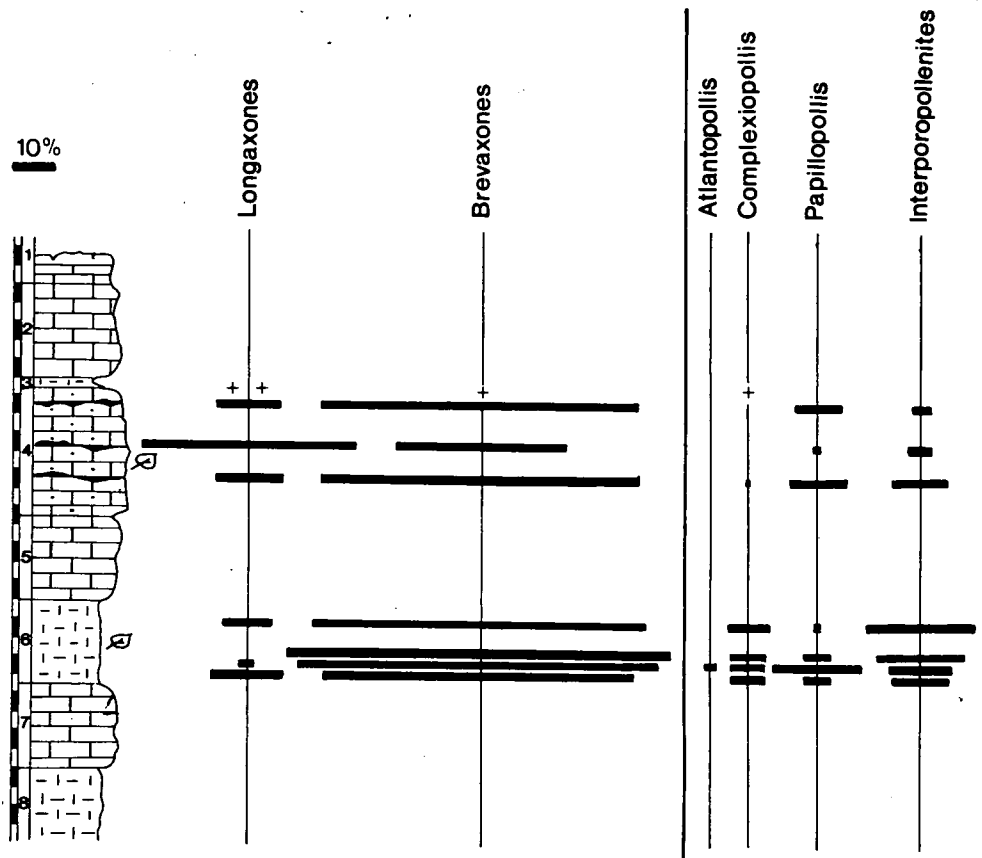

Figura 4. 4.

que son los tipicos de las *Angiospermas* primitivas. Estas formas caracterizan el Cretácico superior, época en que destacan por su cantidad y diversidad los *Normapólenes.* Como puede observarse en esta figura todos los niveles presentan una gran desproporción entre los porcentajes de los pólenes *Brevaxones* y *Longaxones* en favor de los primeros, a excepción del nivel intermedio del tramo 4 en que ambos son muy semejantes. Dado el interés que representan las formas *Breviejes* en las dataciones estratigráficas y correlaciones del Cretácico superior se representan en la figura 4.5., porcentajes de los tipos polínicos cuya presencia en los distintos niveles muestreados ha resultado significativa *(Interporopollenites, Papillopollis, Complexiopollis* y *Atlantopollis).*

Discusión de resultados

Las especies y formas esporopolínicas halladas en el yacimiento del Cerro de la Mesa son, en lineas generales, las mismas que hemos determinado en los otros

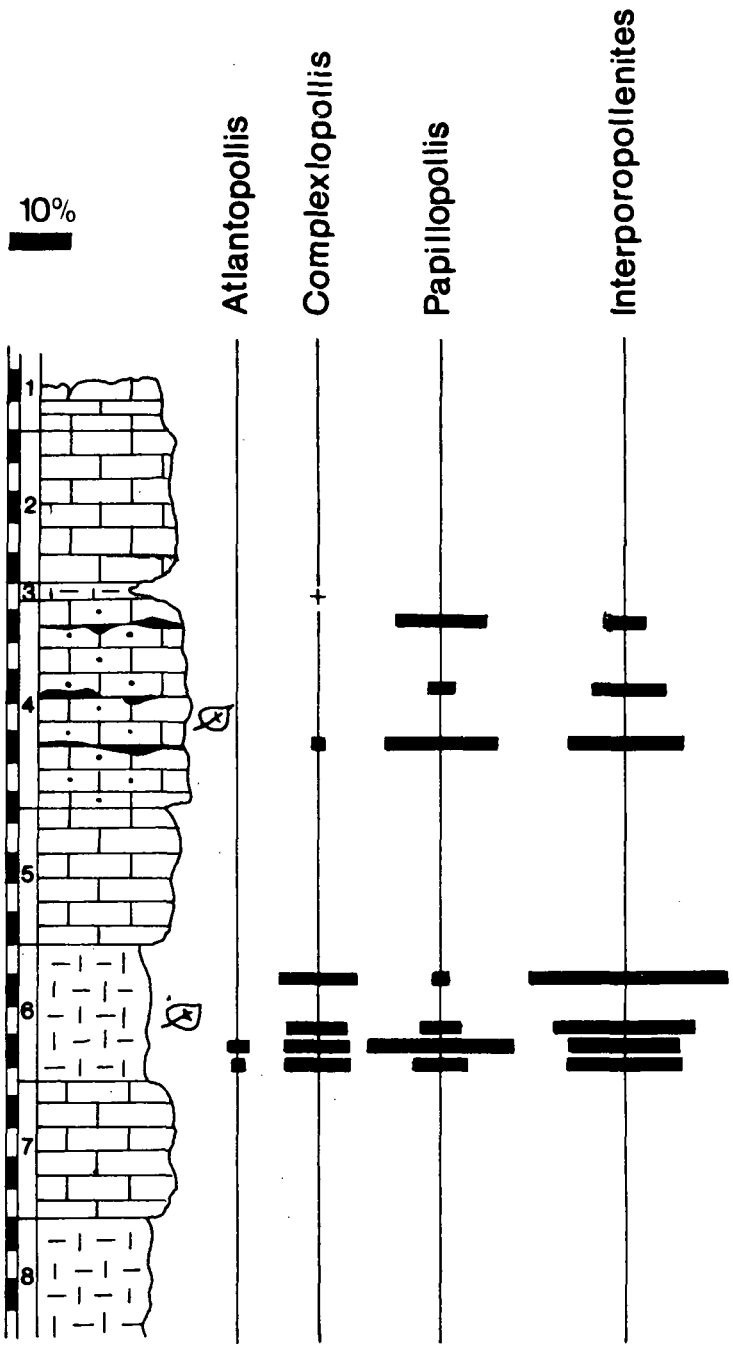

Figura 4.5.

yacimientos estudiados en el Cretácico superior del Borde Sur de la Sierra de Guadarrama.

No obstante la presencia o abundancia de formas con valor cronoestratigráfico, especialmente palinomorfos pertenecientes a *Angiospermas* primitivas y/o a quistes de *Dinoflagelados* nos permite especular con más precición acerca de la posición estratigráfica de los niveles estudiados. La dominancia, entre los *Normapólenes,* de *Interporopollenites,* asi como la variedad de tipos de *Papillopollis* y de *Dinoquistes* (estos serán estudiados posteriormente por un especialista en la materia) entre los que creemos reconocer diversos tipos de *Deflandrea, Weitzellites* y sobre todo la abundancia de *Mycrodinium* afin a *M. veligerum* o a *M. kustanaikum* que son formas que caracterizan el Campaniense y Maastrichtiense, parecen datar los niveles estudiados.

Si se comparan las asociaciones encontradas en el Cerro de la Mesa con las de otros yacimientos del borde meridional de la Sierra de Guadarrama no se observan diferencias notables, como ya se ha indicado anteriormente.

En relación a la palinoflora descrita en Torrelaguna (ALVAREZ RAMIS y DOUBINGER, 1980) existen numerosas formas comunes, sobre todo las más recientes. El yacimiento fué atribuido al intervalo sedimetario Cenomaniense superior-Santoniense. Si se compara con otros yacimientos más o menos sincrónicos de la Peninsula Ibérica, aparecen tipos polínicos semejantes a los descritos en Vila Flor (Cenomaniense superior-Turoniense) y Carrajão (Turoniense-Coniaciense) por DINIZ, KEDVES y SIMONCSICS en 1974 y en Aveiro (Santoniense-Campaniense) por KEDVES y DINIZ en 1967. Hay que destacar en Cerro de la Mesa la frecuencia relativa de *Rocheipollenites triangulus* y la presencia de *Aveiropollenites triangulus* descritos por primera vez en Portugal y escasos en la localidad tipo.

La coincidencia entre los palinomorfos hallados en nuestro yacimiento y la de los que integran las diferentes paleoasociaciones cretácicas de la Península Ibérica, junto con la abundancia de *Interporopollenites* y *Papillopollis,* presencia de formas triporadas de tipo actual y de *Dinoflagelados* que caracterizan las series finicretácicas (Campaniense-Maastrichtiense) parecen reforzar la datación propuesta para los niveles muestreados en el Cerro de la Mesa como al menos Campaniense.

La iconografía de los *Normapólenes* de mayor interés se ha figurado, por los autores en Plant Cell Biology and Development 4, 22–25, y un aspecto general de la paleoasociación se da a conocer en la lámina del trabajo presentado al 9º Simposio de Palinología; Las Palmas de Gran Canaria – España 1992.

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5. TEM STUDY OF THE "INFECTED" POLLEN GRAINS OF THALICTRUM FLAVUM L. WITH GLIOCLADIUM ROSEUM (LINK) BAINIER

Short communication

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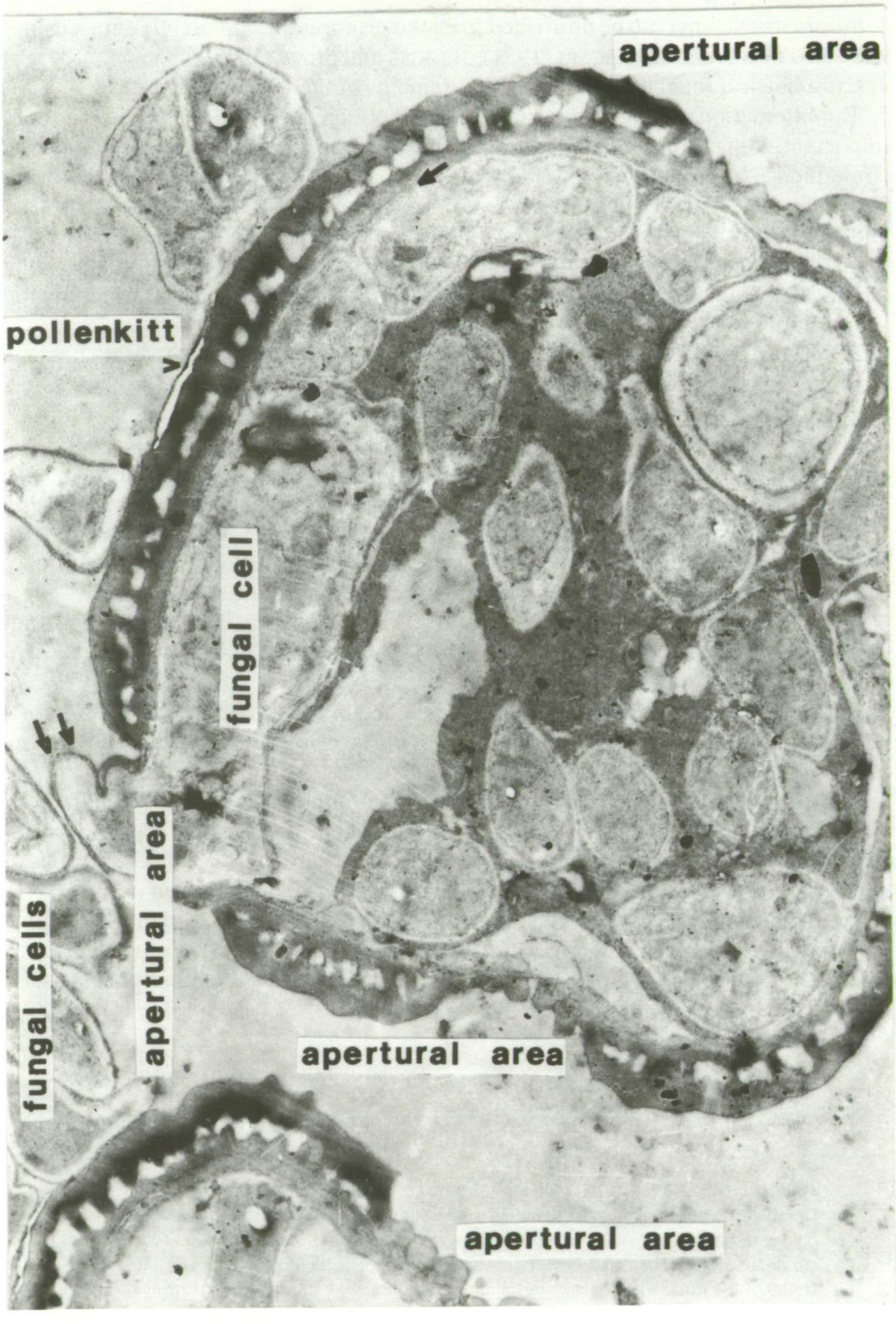
During our experimental investigations of the secondary alterations of the spores and pollen grains (e. g.: KEDVES and KINCSEK, 1989, KEDVES and PÁRDUTZ, 1992a), several taxa were examined. The pollen grains of the interesting, wind-pollinated *Ranalean* genus – *Thalictrum* – were also the subjects of our investigations. On 17. 6. 1988, 20 mg air dried pollen material was mesured six times in small glasses for high temperature effect experiments. Not long after the preparation of the experiment, symptoms of infections were observed. The infected pollen grains were placed into a thermostat at 30 °C for $24^{hrs.}$. The determination of the microscopical fungi was made in the Department of Microbiology of the J. A. University, by Dr. L. MANCZINGER, as *Gliocladium roseum* (LINK) BAINIER. The infected material was fixed (OsO_4 aq. dil. 1%), embedded in Araldite, ultrathin sectioned, and investigated with the TEM method. The electron microscopical pictures were taken with a Tesla BS-500 transmission electron microscope; resolution: 6 Å. Our preliminary results can be summarized as follows.

1. Fungal cells, mostly hyphae were observed intramatrically (inside the pollen grain) and extramatrically (outside the pollen grain); cf. HESSE, KUSEL-FETZMANN and CARNIEL, (1989) (Plate 5.1., plate 5.2., figs. 1,2).
2. Intramatrical fungal cells can grow through the aperture of the pollen grain, and this kind of hypha is similar to the pollen tube; Plate 5.1., marked with two arrows.

Plate 5.1. ▸

Thalictrum flavum L. Recent pollen grain with *Gliocladium roseum* (LINK) BAINIER.

The fungal cells are shown in the protoplasm of the pollen grains and outside the exine. It is worth mentioning that several fungal cells reach the plasma membrane of the pollen grain. Marked with an arrow. One of them is growing out through the pollen aperture pushing out the thin exine layer of the germinal area. Indicated with two arrows. The thin electron dense coat layer on the surface is well shown. Extramatrical fungal cells may be in close contact with the surface of the pollen grain.
Negative no: 8946, 10.000 x.


apertural area
pollenkitt
fungal cell
apertural area
fungal cells
apertural area
apertural area

3. Intramatrical fungi can be nourished from the protoplasm, completely empty exines were also observed. Cf.: FAEGRI (1971), BROOKS and SHAW (1973).
4. Extramatrical fungi can also digest the remains of the tapetal tissues.
5. The interactions between the surface of the pollen grain and the fungal cells are important. Fungal cells can grow directly towards the pollen grain. This can be the consequence of several factors, as follows.

5.1. The peculiar biopolymer system of the pollen surface (cf. KEDVES, PÁRDUTZ, and VÉR, 1991, KEDVES and PÁRDUTZ, 1992b).

5.2. The electrostatic charge of the pollen surface (ROWLEY, 1971), namely the anionic character, which results in the accumulations of the cations, particularly the thorium on the surface.

5.3. The peculiar characteristics of the pollen coat (tryphine). Several concepts were published concerning this question; EHRLICH (1958), FREYTAG, (1967), SKVARLA and ROWLEY (1970), DICKINSON and LEWIS (1973), HESLOP-HARRISON (1975), MASCARENHAS (1975), GILLISSEN and BRANTJES (1978), HESSE (1978a, b, c, 1979, 1980, 1984, 1991), AUDRAN and BATCHO (1981), ZAVADA (1983), BLACKMORE and BARNES (1984), LOEWUS et al. (1985), SOUTHWORTH (1985), FERNÁNDEZ and RODRIGUEZ-GARCIA (1988), HARLEY (1988, 1991), DICKINSON and SHELDON (1990), VAN DER HAM (1990), ROMAN, BLANCA and ROMERO (1992). The chemical interaction between the surfaces of the fungal cell and the pollen grain is also a factor in this phenomenon.

5.4. The molecular sieving character of the exine (ROWLEY, 1973) is also important and so is the basic concept of ROWLEY (1987–88) which says that the "pollen wall" is an integrated part of the plasma membrane.

5.5. The plasma membrane and the tapetal membrane glycocalyx are also important in this interaction. The fungal cell, which is in connection with the plasma membrane (glycocalyx), can "imitate" the pollen tube.

6. According to the newest concept of fungal-plant interactions, the following can be cited from the book of ISAAC (1992), p. 316: "There is presently a great deal of discussion concerning the extent to which endophytes are in fact latent pathogens of exampes of fungi co-evolving with plants from parasitism to mutualism (CLAY, 1988). However in many cases mutualistic relationships between host plants and fungi endophytes are suspected and in many instances such associations have been identified." P. 320. "Many endophytes live almost entirely within the host plant tissues, often without causing any visible signs of infection."

Plate 5.2. ▸

Thalictrum flavum L. Recent pollen grain with *Gliocladium roseum* (LINK) BAINIER.

1. Detail of the pollen exine ultrastructure with a fungal cell on the surface. The contact between the pollen and fungal cell surfaces is very close in some parts. The disintegration (digestion by fungal enzymes) of the pollen coat is well shown. negative no: 8614, 40.000x.
2. Detail of the exine with remains of the tapetal tissues. One fungal cell is growing directly towards the pollen exine. On the tectum, the thin electron dense layer, the pollen coat is well illustrated. Negative no: 8589, 20.000x.

2
fungal cell
1
fungal cell
Tectum
Infratectum
Foot layer

In resumé, the observed fungal-pollen interaction is a complicated, multifactorial biochemical and physiological relationship.

Finally it is necessary to emphasize that to get more information about the relationship of the connected surfaces of the pollen and the fungal cell, we need further TEM data with an instrument of better resolution power. These investigations are in progress, and the new results will be published in the near future.

The authors are deeply indebted to Prof. DR. L. FERENCZY, member of the Hungarian Academy of Sciences, and to DR. L. MANCZINGER, first assistant (Department of Microbiology of the J. A. University, Szeged, Hungary) for their valuable comments and advice.

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6. BUCKMINSTERFULLERENE-LIKE BIOPOLYMER UNITS FROM THE EXINE OF THALICTRUM FLAVUM L.

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Abstract

On the TEM micrographs of the partially degraded and fragmented exines of *Thalictrum flavum* L., quasi-equivalent biopolymer structures were observed for the fisrst time from *angiosperm* exines. The diameter of the large globular units is 15 – 35 – 85 Å, and the diameter of the superficial electron dense particles is 5 – 10 – 15 Å. The arrangement of these large globular units may be linear, irregular or they may form network systems of different kinds of polygons. Further peculiarities of the pollen grains of the wind-pollinated *Thalictrum* genus were established experimentally. The quasi-equivalent biopolymer structures were discovered in the partially degraded wall of *Botryococcus braunii* KÜTZ. isolated from oil shale. These structures can be modelled with fullerenes.

Key words: Palynology, recent, *Angiospermae,* quasi-equivalent biopolymer structure.

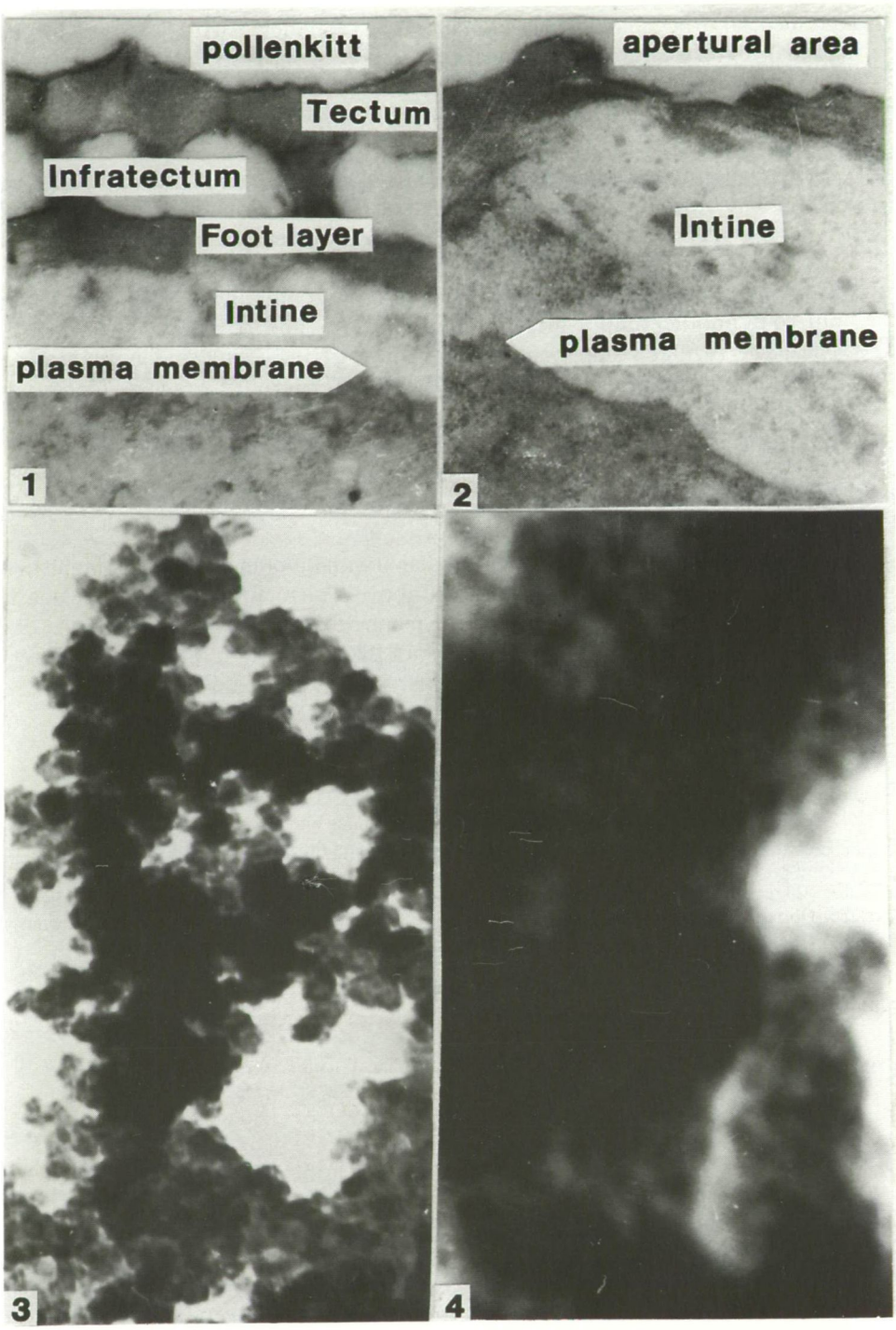
Introduction

During our investigations on the biopolymer structure and organization levels of the plant cell wall, surprising and unusual biopolymer units were observed on the partially degraded and fragmented wall of *Botryococcus braunii* KÜTZ. extracted from the oil shales of Hungary (KEDVES, ROJIK and VÉR, 1991). The peculiarities of the biopolymer organization of the fossil *Botryococcus braunii* wall were the subjects, among others, of further investigations (KEDVES, ROJIK and VÉR, 1992). The previous-

Plate 6.1. ▸

1–4. *Thalictrum flavum* L. Recent.

1. Ultrastructure of the interapertural area of the fresh (non-experimental) pollen grain. Negative no: 8550, 50.000x.
2. Exine ultrastructure of the apertural area of the fresh (non-experimental) pollen grain. Negative no: 8552, 50.000x.
3. Experiment No: 281, globular highly organized biopolymer structures from partially degraded and fragmented exine. Negative no: 9816, 100.000x.
4. Experiment No: 266, detail from the highly organized buckyball-like biopolymer structure. The superficial electron dense molecular systems are well shown. Negative no: 9753, 500.000x.


pollenkitt
Tectum
Infratectum
Foot layer
Intine
plasma membrane
1
apertural area
Intine
plasma membrane
2
3
4

ly described, large peculiar, and globular units can be modelled with fullerenes having a buckyball-like structure; review of the fullerenes from BECK and BRAUN (1992). Taking into consideration our up-to-date knowledge about chemistry and biopolymer structures, the following scheme can be summarized:

1. Chemical compounds of the plant cell wall.

2.1. Basic regular pentagonal biopolymer units of angstroem dimension (8 – 22 Å). These units from the quasi-crystalloid metastable skeleton of the plant cell wall in pentagon dodecahedrane systems. Such biopolymer systems can be modelled after the theory from PENROSE's tiling patterns (PENROSE, 1979).

2.2. In living systems, the metastable quasi-crystalloid biopolymer skeleton is stabilized by another biopolymer system (Cf. KEDVES and TÓTH, 1992, 1994).

2.3. The basic regular pentagonal dodecahedron of the PENROSE–I units are the elementary components of the units of a further level of organization in nanometer dimension filaments, lamellae, helical, tubular (ROWLEY et al., 1981), globular (HESSE, 1985), irregular polygons (SOUTHWORTH, 1986), etc.

2.4. The colloidal-crystal-like organization (HEMSLEY, COLLINSON and BRAIN, 1992) can be joint to the previous organization level. But this time its lower or elementary biopolymer units are not well known.

3. The biopolymer units, which can be modelled with fullerenes can be distinguished from the biopolymer systems mentioned above. The relations between the quasi-crystalloid and quasi-equivalent biopolymer systems are under elaboration.

Previously it was believed that the buckyball-like biopolymer units are characteristic for the wall of "peculiar living organisms" such as the genus *Botryococcus.*

Materials and Methods

The pollen grains were collected by Dr. L. TÉCSI from the Botanical Garden of the J. A. University, Szeged, on 20th June 1988. Fresh, non-experimental pollen grains were also used in TEM investigations for comparisons. The experiments started on 20th June 1988 and the different kinds of experiments are the following.

No 265: 20 mg air dried pollen grains + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h.

No 280: the pollen grains were heated onto 100 °C for 1 hour, after being partially degraded as previously (265).

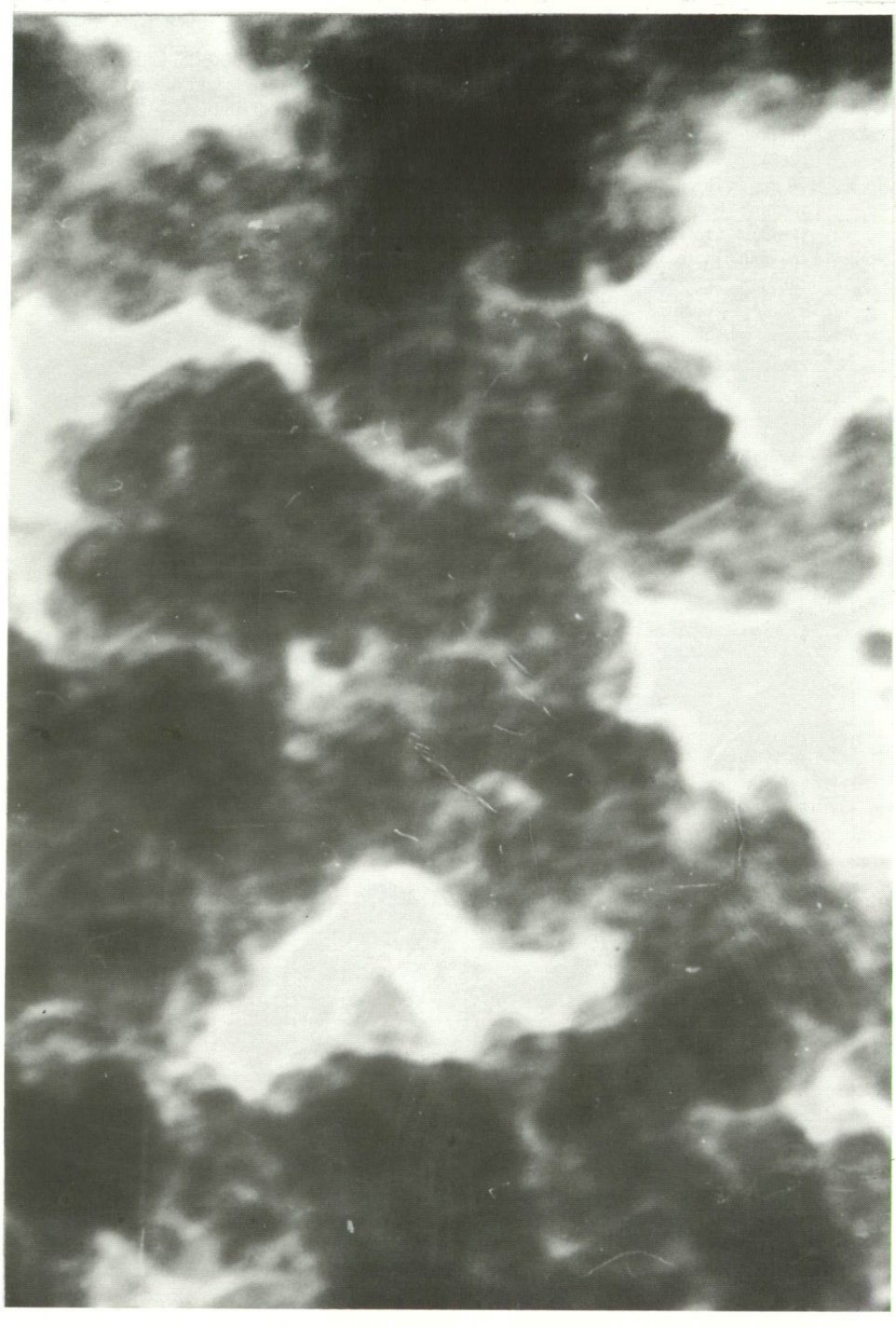
No 266: 20 mg air dried pollen grains + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h, washing (H_2O) + 10 ml $KMnO_4$ aq. dil. 1%, temperature 30 °C, length of time 24^h.

No 281: the pollen grains were heated onto 100 °C for 1 hour, after being partially degraded as previously (266).

No 267: 20 mg air dried pollen grains + 1 ml 2-aminoethanol, temperature 30 °C, lenght of time 24^h, washing (H_2O) + 10 ml $KMnO_4$ aq. dil. 1%, temperature 30 °C, lenght of time 48^h.

Plate 6.2. ▸

Thalictrum flavum L. Recent.
Experiment No: 282, buckyball-like highly organized biopolymer structures from partially degraded and fragmented exine. The superficial electron dense molecular units and the partial degradation process are well illustrated.



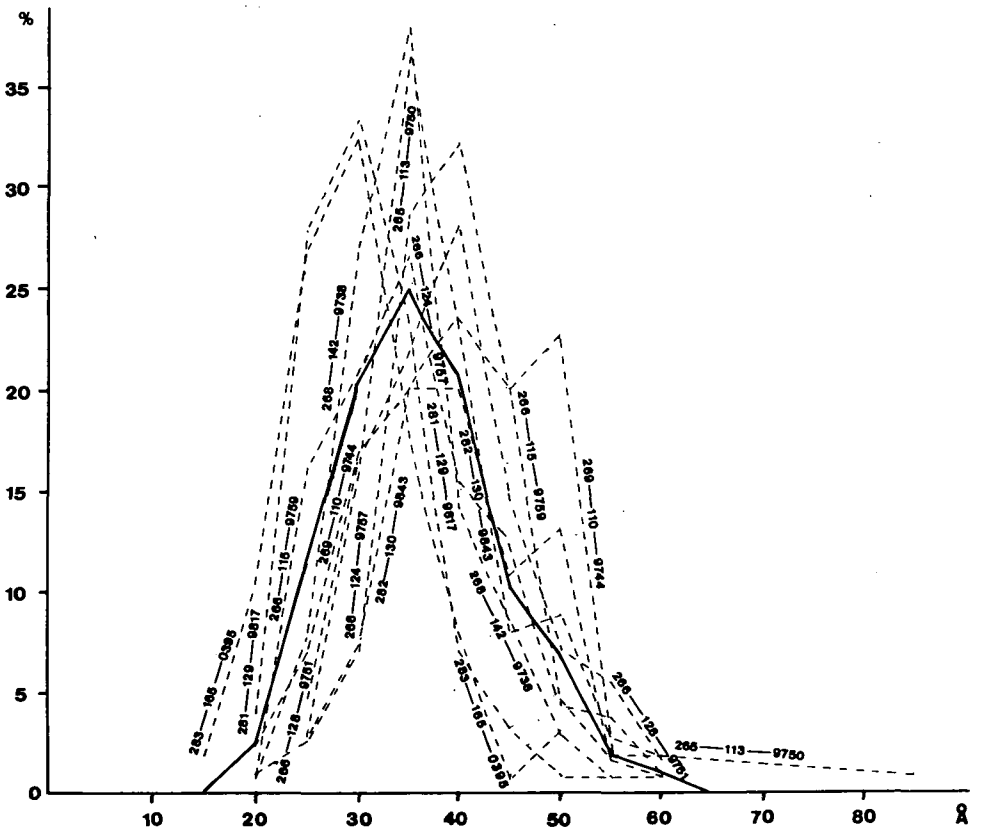
No 282: the pollen grains were heated onto 100 °C for 1 hour, after being partialIly degraded as previously (267).

No 268: 20 mg air dried pollen grains + 1 ml 2-aminoethanol, temperature 30 °C, lenght of time 24^h, washing (H_2O) + 10 ml $KMnO_4$ aq. dil. 1%, temperature 30 °C, lenght of time 24^h, washing (H_2O) + 2 ml acetic acid anhydride, temperature 30 °C, lenght of time 24^h.

No 283: the pollen grains were heated onto 100 °C for 1 hour, after being partially degraded as previously (268).

No 269: 20 mg air dried pollen grains + 1 ml 2-aminoethanol, temperature 30 °C, lenght of time 24^h, washing (H_2O) + 10 ml $KMnO_4$ aq. dil. 1%, temperature 30 °C, lenght of time 24^h, washing (H_2O) + 5 ml methanol, temperature 30 °C, lenght of time 24^h.

No 284: the pollen grains were heated onto 100 °C for 1 hour, after being partially degraded as previously (289).



Text-fig. 6.1.

Variation statistical graphs of the diameter of the highly organized buckyball-like biopolymer structures. The thick line represents the general average of all measurements, the broken lines represent that of the results by experiments or sometimes by negatives. The numbers of the graphs represent the following: number of experiment, number of the measured biopolymer units, number of the negative.

Ultrathin sections were made on a Porter Blum ultramicrotome with glass knives (post-fixation with OsO_4 aq. dil. embedding in Araldite Durcupan, Fluka). The fragmentation was made with a magnetic stirrer in watered medium, during 30 minutes. The fragmented exines were dropped on a grid covered with collodium pellicle and then they were dried. The electron microscopical investigations were made on a Tesla BS-500 transmission electron microscope, resolution 6 Å.

Results

LM morphology: "16μ. – Grains cribellate with about 8 pores. Exine with reticulate texture." (ERDTMAN, 1954, p. 120); "6–12 pantoporate" (CLARKE, PUNT and HOEN, 1991, p. 146).

TEM structure of the fresh pollen grains.

Interapertural exine (Plate 6.1., fig. 1). – Tectate, tectum perforated with channels, and ornamented with coni of different size and shape. The surface of the tectum is covered with pollenkitt (cf. HESSE, 1978, p. 20 .."auf dem Tectum liegen geringfügige Mengen teiweise granulären Pollenkitts...") Infratectal layer columellar. The foot layer is a bit thinner than the tectum. Beneath the foot layer, the interbedded zone was observed (cf. FREAN, 1973, KEDVES and ANTUNOVICS, 1979). The intine is thick, the plasma membrane is thin.

Apertural exine (Plate 6.1., fig. 2). – The ectexine is extremely reduced, and pro parte fragmented (cf. ROLAND, 1966). The intine in this area is thicker than extragerminally; oncus-like.

TRANSMISSION ELECTRON MICROSCOPY OF THE PARTIALLY DEGRADED AND FRAGMENTED EXINES

Experiment No: 265 (Text-fig. 6.1.)

Globular biopolymer units were observed in several kinds of arrangements, linear, network-like, irregular polygons. Diameter: 25 – 35 – 85 Å. The typical buckyball-like biopolymer characteristic features were not observed.

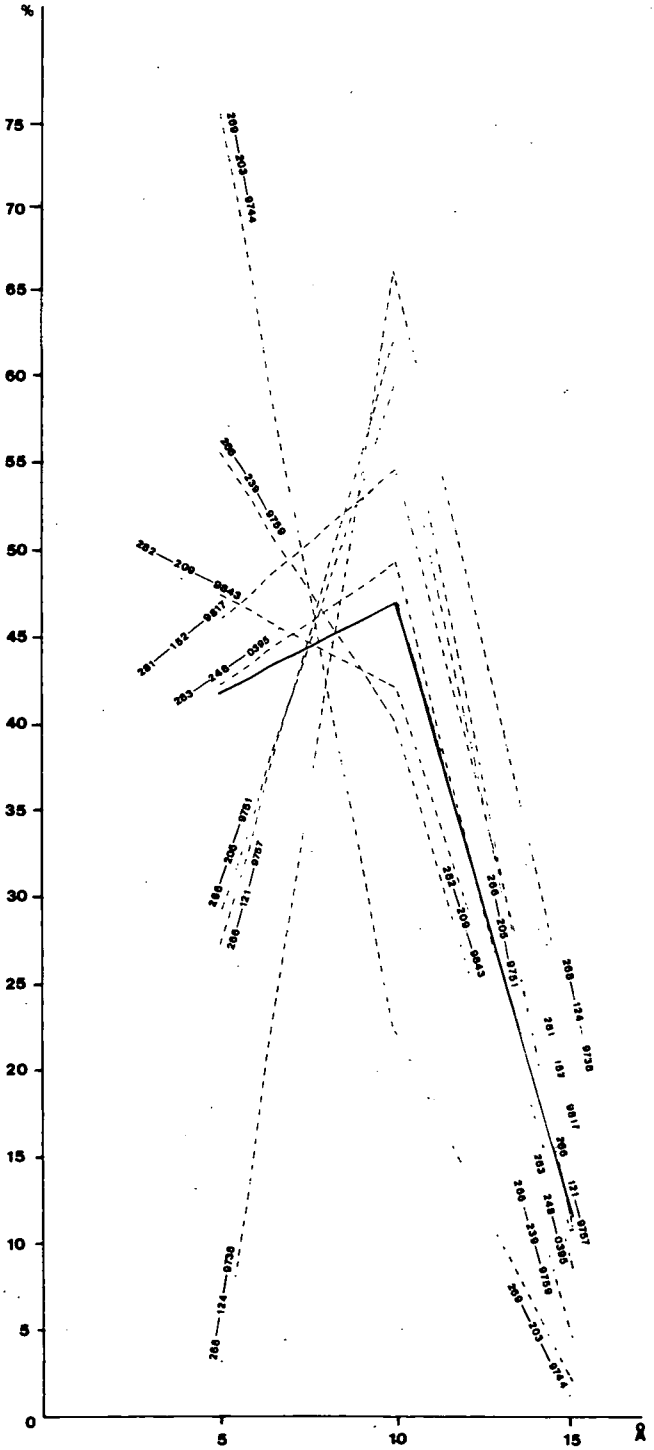
Experiment No: 280

Our TEM data are not sufficient in this respect, this may be the consequence of methodical problems.

Experiment No: 266 (Plate 6.1., fig. 4, text-fig. 6.1., 6.2.)

Globular units of several kinds of arrangements were observed. In highly magnified pictures, not so characteristic buckyball type biopolymer units were observed, large globular units with smaller electron dense superficial molecular systems. In this experiment, the measurements were made on three negatives, the data are not the same;

Negative number	Diameter of the globular units in Å	Diameter of the superficial molecular systems in Å
9751	25 – 40 – 60	5 – 10 – 15
9757	20 – 35 – 60	5 – 10 – 15
9759	20 – 45 – 60	5 – 10 – 15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Experiment No: 281 (Plate 6.1., fig. 3, text-fig. 6.1., 6.2.)
This experiment resulted essentiallly the previously discussed one; diameter of the globular biopolymer units: 20 – 30 – 60 Å, diameter of the superficial electron dense molecular systems: 5 – 10 – 15 Å.
Experiment No: 267
The qualitative results are similar to those of the experiment No 266, but the biopolymer units were not suitable for quantitative measurements.
Experiment No: 282 (Plate 6.2., text-fig. 6.1., 6.2.)
The buckyball-like biopolymer structures are well shown in our pictures but in several particles of the fragmented exine advanced degradation process was observed. Diameter of the large globuar units: 20 – 35, 40 – 60 Å, diameter of the superficial electron dense molecular systems: 5 – 10 – 15 Å.
Experiment No: 268 (Text-fig. 6.1., 6.2.)
Similar to the previously mentioned ones. Diameter of the large globular units: 20 – 35 – 60 Å, diameter of the superficial electron dense molecular systems: 5 – 10 – 15 Å.
Experiment No: 283 (Text-fig. 6.1., 6.2.)
The globular biopolymer units are relatively smaller than in the previous experiments; 15 – 30 – 50 Å, the size of the superficial electron dense molecular systems is constant; 5 – 10 – 15 Å.
Experiment No: 269 (Text-fig. 6.1., 6.2.)
Diameter of the large globular biopolymer units: 25 – 40 – 60 Å. Diameter of the superficial electron dense molecular systems: 5 – 10 – 15 Å.
Experiment No: 284
Advanced disintegration of the biopolymer structure was observed. The quasi-equivalent structures were not in a measurable preservation.

Discussion and Conclusions

1. The buckyball-like biopolymer structure was first observed on *angiosperm* exines. In this way this may occur in other taxa too.
2. The new results underlined newly that the molecular system of the plant cell wall is extremely complicated. Several kinds of structures can be established.
3. The sporopollenin-type plant cell wall is resistant, but as we have pointed it out several times previously this extremely complex molecular system is a dinamically and perpetually altering structure.
4. The chemical compound of the plant cell wall, and its highly organized structures on several organization levels are not unique, either, and it seems that after last time's obtained results, several details need more and more investigations.

◂ Text-fig. 6.2.

Variation statistical graphs of the diameter of the superficial electron dense molecular systems. Thick line represents the general average of all measurements, the broken lines represent of the results by experiment or sometimes by negatives. Numbers of the graphs represent the following: number of experiment, number of the measured electron dense superficial molecular systems, number of the negative.

Acknowledgements

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7. INCOMPLETE AND NON-FIVEFOLD ROTATION OF THE BASIC BIOPOLYMER UNIT OF THE EXINE OF PINUS GRIFFITHII MCCLELL

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Abstract

In this paper the results of the incomplete and non-fivefold rotation method applied to the basic pentagonal biopolymer unit of *Pinus griffithii* MCCLELL are presented. This is a new contribution to the method of the basic pentagon biopolymer unit of the sporoderm.

Key words: Palynology, exine, biopolymer structure, rotation method.

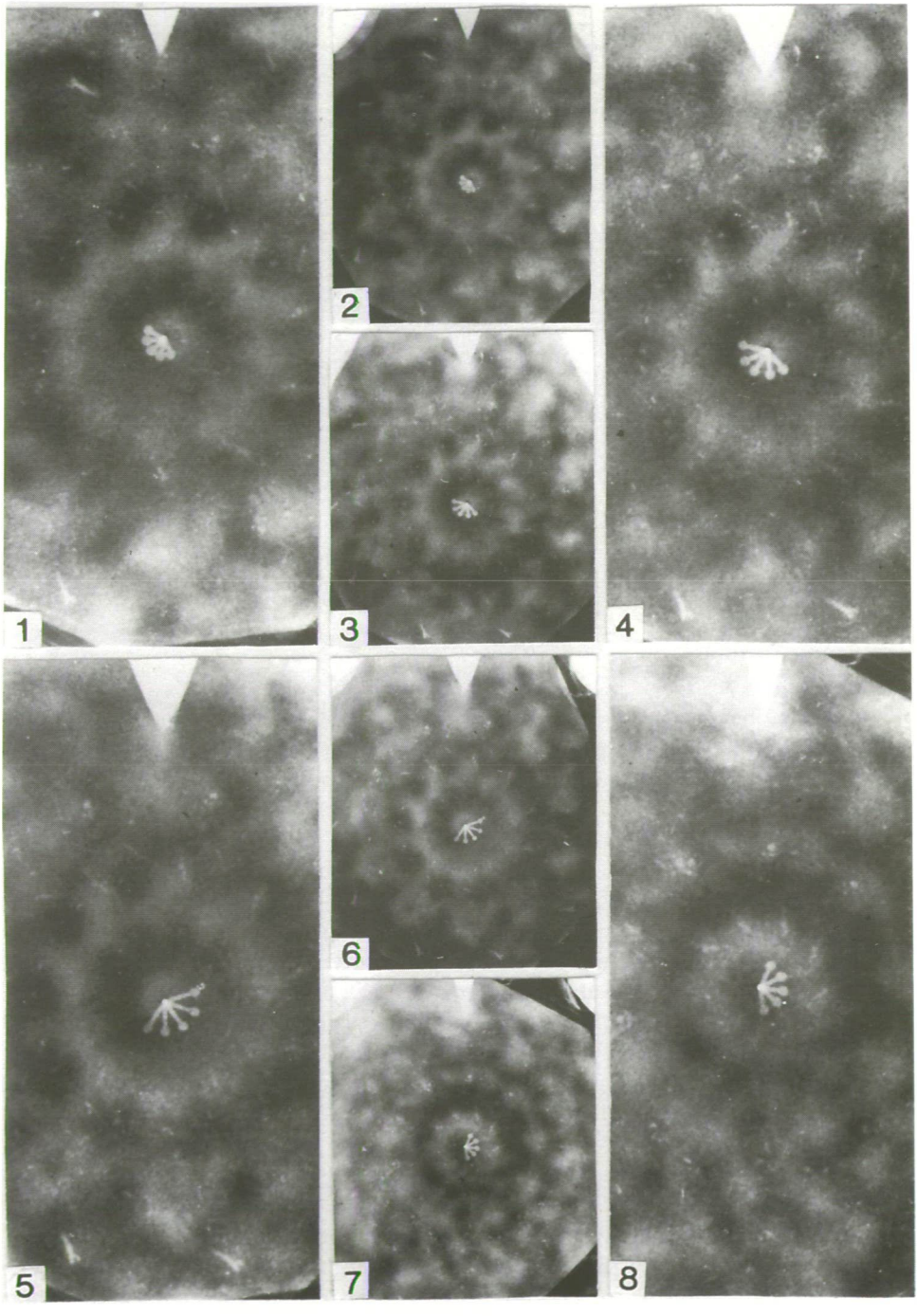
Introduction

It was not long after the discovery of SHECHTMAN, BLECH, GRATIAS and CAHN (1984) that in 1988 the presence of the quasi-crystalloid biopolymer structure in living system was first reported from the partially degraded exine of *Pinus griffithii* MCCLELL (KEDVES, 1988). The research program of this subject has split into several directions. One of them is the basic, two-dimensional field which uses the modified MARKHAM rotation method (e. g., KEDVES, 1989, 1990, KEDVES and FARKAS, 1991, etc.).

In the first methodical paper (KEDVES, 1989) the incomplete and non-fivefold rotation of the regular pentagonal polygon biopolymer system in angstroem dimension was also pointed out as a theoretical possibility. Until now, the non-fivefold rotation method has been used in peculiar cases such as the symmetry operations of the TICOS polyhedra modelling to the biopolymer system (KEDVES, 1991) and to the peculiar biopolymer network of the partially degraded and fragmented wall of *Botryococcus braunii* KÜTZ. isolated from the Upper Tertiary oil shale of Hungary (KEDVES, TÓTH and FARKAS, 1993, in print).

Material and Methods

As it has been emphasized several times in a number of publications (cf. SOUTHWORTH, 1986), the basis of partial degradation is the heterogeneity of the different components of the sporoderm, in general, of the ultrastructural elements of the living systems. In this way the solubility and the resistance of the different components is not the same. Using partial degradation before the TEM method, we obtained several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data concerning the biopolymer organization of the plant cell wall on different levels. Since this paper is essentially a new methodical contribution to the actual investigations, we have used the basic regular pentagonal unit, discovered first, which was published in several papers before (cf. KEDVES, 1989).

Results

INCOMPLETE ROTATION METHOD
(Plate 7.1., figs. 1–8, plate 7.2., figs. 1–4)

Designations:
I = Incomplete rotation; the total of the angles of rotation is below 360 °.
P = Primary rotation; the centre of rotation is the middle of one biopolymer unit observed with direct TEM method.

I.P.5.A.5.10/2,1–5. (Plate 7.1., figs. 1,2)

In the case a regular fivefold biopolymer unit rotated with the starting AP axis around the first half of the tenfold rotation (C.P.5.A.5.10). 10/2,1–5 indicate, that the expositions were made at the first five rotation axes as follows:

1st exposition – at the 1st globular biopolymer unit of the regular basic pentagon,
2nd exposition – at the central point of the 1st and 2nd globular biopolymer units of the regular basic pentagon,
3rd exposition – at the 2nd globular biopolymer unit of the regular basic pentagon,
4th exposition – at the central point of the 2nd and 3rd globular biopolymer units of the regular basic pentagon,
5th exposition – at the 3rd globular biopolymer unit of the regular basic pentagon.

Short: this rotation may be designated: A – B – A – B – A. Three globular units and two central points.

I.P.5.A.5.10/2,2–6. (Plate 7.1., figs. 3,4)

1st exposition – at the central point of the 1st and 2nd globular biopolymer units of the regular basic pentagon,
2nd exposition – at the 2nd globular biopolymer unit of the regular basic pentagon,
3rd exposition – at the central point of the 3rd and 4th globular biopolymer units of the regular basic pentagon,

◂ Plate 7.1.

1–8. *Pinus griffithii* MCCLELL. Recent. Experiment No: 79, negative no: 7451. Incomplete rotation pictures.
1. I.P.5.A.5.10/2,1–5. 1 Million.
2. I.P.5.A.5.10/2,1–5. 500.000x.
3. I.P.5.A.5.10/2,2–6. 500.000x.
4. I.P.5.A.5.10/2,2–6. 1 Million.
5. I.P.5.A.5.10/2,3–7. 1 Million.
6. I.P.5.A.5.10/2,3–7. 500.000x.
7. I.P.5.A.5.10/2,4–8. 500.000x.
8. I.P.5.A.5.10/2,4–8. 1 Million.

4th exposition – at the 3rd globular biopolymer unit of the regular basic pentagon,
5th exposition – at the central point of the 3rd and 4th globular biopolymer units of the regular basic pentagon.

Short: this rotation may be designated: B – A – B – A – B. Three central points and two globular biopolymer units.

I.P.5.A.5.10/2,3–7. (Plate 7.1., figs. 5,6)

1st exposition – at 2nd globular biopolymer unit of the regular basic pentagon,
2nd exposition – at the central point of the 2nd and 3rd globular biopolymer units of the regular basic pentagon,
3rd exposition – at the 3rd globular biopolymer unit of the regular basic pentagon,
4th exposition – at the central point of the 3rd and 4th globular biopolymer units of the regular basic pentagon,

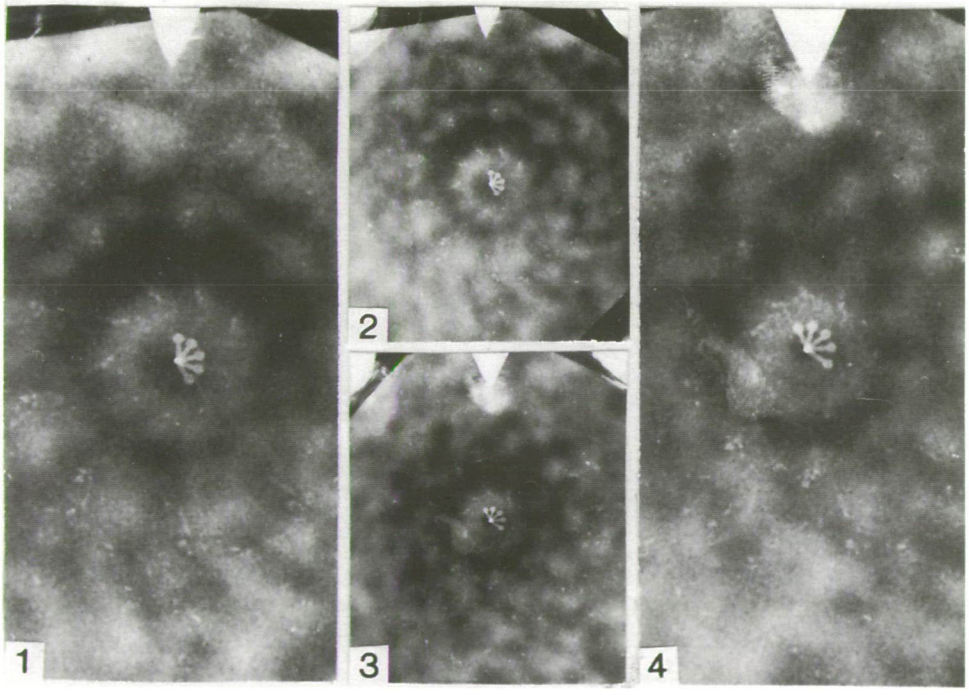


Plate 7.2.

1–4. *Pinus griffithii* McCLELL. Recent. Experiment No: 79, negative no: 7451. Incomplete rotation pictures.
1. I.P.5.A.5.10/2,5–9. 1 Million.
2. I.P.5.A.5.10/2,5–9. 500.000x.
3. I.P.5.A.5.10/2,6–10. 500.000x.
4. I.P.5.A.5.10/2,6–10. 1 Million.

5th exposition – at the 4th globular biopolymer unit of the regular basic pentagon.
Short: this rotation may be designated: A – B – A – B – A. Three globular units and two central points again.

I.P.5.A.5.10/2,4–8. (Plate 7.1., figs. 7,8)

1st exposition – at the central point of the 2nd and 3rd globular biopolymer units of the regular basic pentagon,
2nd exposition – at the 3rd globular biopolymer unit of the basic regular pentagon,
3rd exposition – at the central point of the 3rd and 4th globular biopolymer units of the regular basic pentagon,
4th exposition – at the 4th globular biopolymer unit of the regular basic pentagon,
5th exposition – at the central point of the 4th and 5th globular biopolymer units of the regular basic pentagon.

Short: this rotation may be designated: B – A – B – A – B. Three central points and two globular units.

I.P.5.A.5.10/2,5–9. (Plate 7.2., figs. 1,2)

1st exposition – at 3rd globular biopolymer unit of the regular basic pentagon,
2nd exposition – at the central point of the 3rd and 4th globular biopolymer units of the basic regular pentagon,
3rd exposition – at the 4th globular biopolymer unit of the regular basic pentagon,
4th exposition – at the central point of the 4th and 5th globular biopolymer units of the basic regular pentagon,
5th exposition – at the 5th globular biopolymer unit of the regular basic pentagon.

Short: this rotation may be designated: A – B – A – B – A. Three globular units and two central points.

I.P.5.A.5.10/2,6–10. (Plate 7.2., figs. 3,4)

1st exposition – at the central point of the 3rd and 4th globular biopolymer units of the basic regular pentagon,
2nd exposition – at the 4th globular biopolymer unit of the regular basic pentagon,
3rd exposition – at the central point of the 4th and 5th globular biopolymer units of the basic regular pentagon,
4th exposition – at the 5th globular biopolymer unit of the regular basic pentagon,
5th exposition – at the central point of the 5th and 1st globular biopolymer units of the basic regular pentagon.

Short: this rotation may be designated: B – A – B – A – B. Three central points and two globular units.

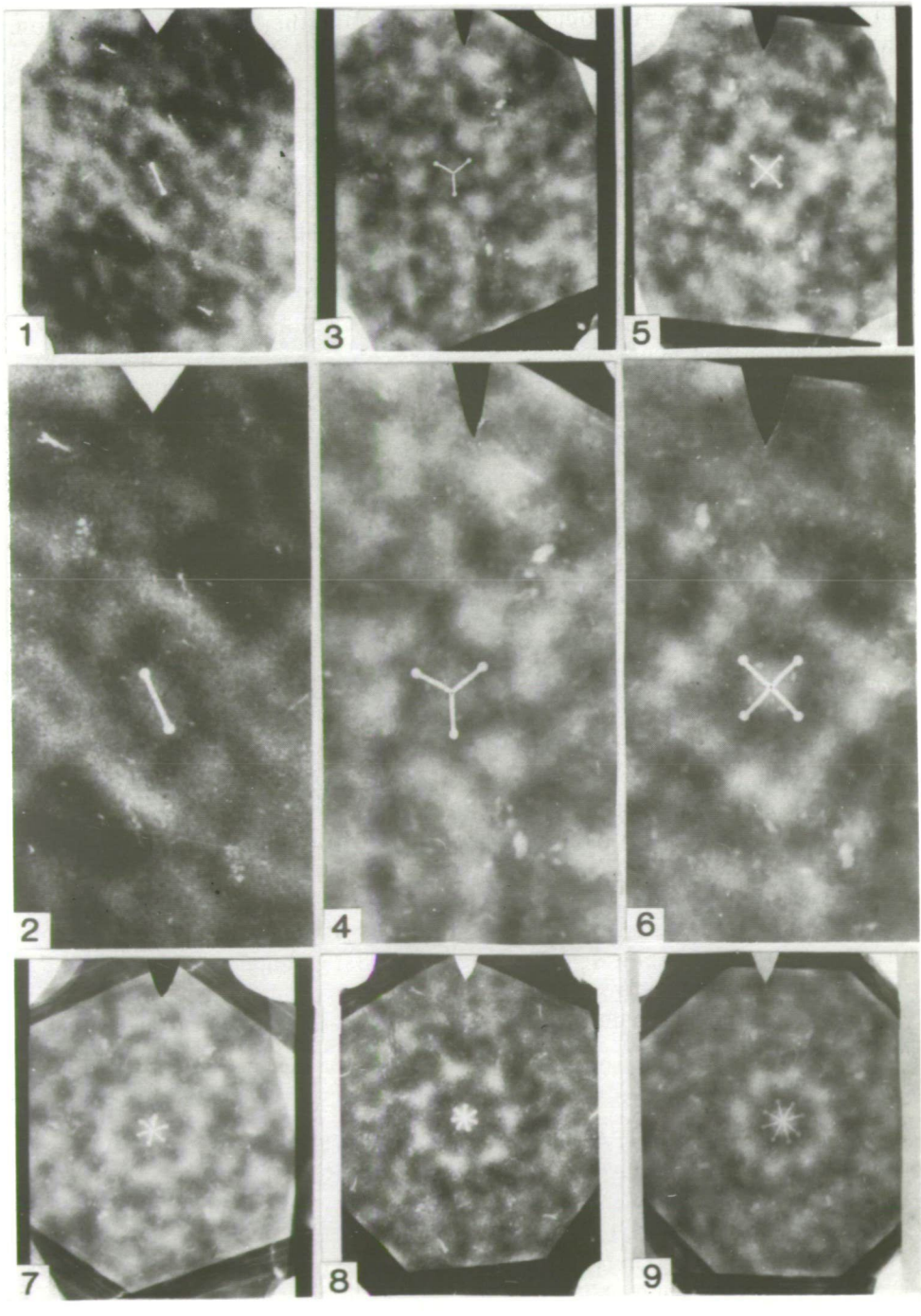
NON-FIVEFOLD ROTATION METHOD OF THE REGULAR BASIC PENTAGONAL BIOPOLYMER UNIT

C.P.5.A.2.2. (Plate 7.3., figs. 1,2)

Interesting secondary points appeared in a peculiar arrangement. This more or less linear biopolymer system is oblique to the PA axis.

C.P.5.A.3.3. (Plate 7.3., figs. 3,4)

In the two circles two times three points of symmetries are reinforced.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C.P.5.A.4.4. (Plate 7.3., figs. 5,6)

Quadrangular points of symmetry appeared with well characterized rotation areas. The discussion of the rotation areas is under preparation in another paper.

C.P.5.A.3.6. (Plate 7.3., fig. 7, plate 7.4., fig. 1)

Interesting circular points of symmetry appeared. These are sexangular in several circles, but the elements of symmetry that appeared in the same circle are not equivalent.

C.P.5.A.7.7. (Plate 7.3., fig. 8, plate 7.4., fig. 2)

This kind of rotation also resulted seven positive and negative points of symmetry together with characteristic rotation areas. But similarly to the previous one, an interesting kind of asymmetry can be observed at the secondary points of symmetry.

C.P.5.A.4.8. (Plate 7.3., fig. 9, plate 7.4., fig. 3)

Negative and positive points of symmetry appeared. The rotation area is almost symmetrical.

C.P.5.A.9.9. (Plate 7.4., figs. 4,5)

This kind of ninefold rotation is essentially the same as the previous one, except for the fact that there are nine positive and nine negative points of symmetry. The rotation area is characteristic.

Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.2.2. (Plate 7.4., figs. 6,7)

Several twofold biopolymer units appeared following this kind of secondary rotation. The whole picture and the orientation is similar to those of the primary twofold rotation of the pentagonal biopolymer unit.

Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.5.5. (Plate 7.5., figs. 1,4)

Very characteristic fivefold positive and negative points of symmetry appeared after this kind of rotation, together with characteristic rotation areas.

Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.4.4. (Plate 7.5., figs. 2,5)

The secondary points that appeared are of tetragonal symmetry with the characteristic rotation areas. The points are more or less duplicate.

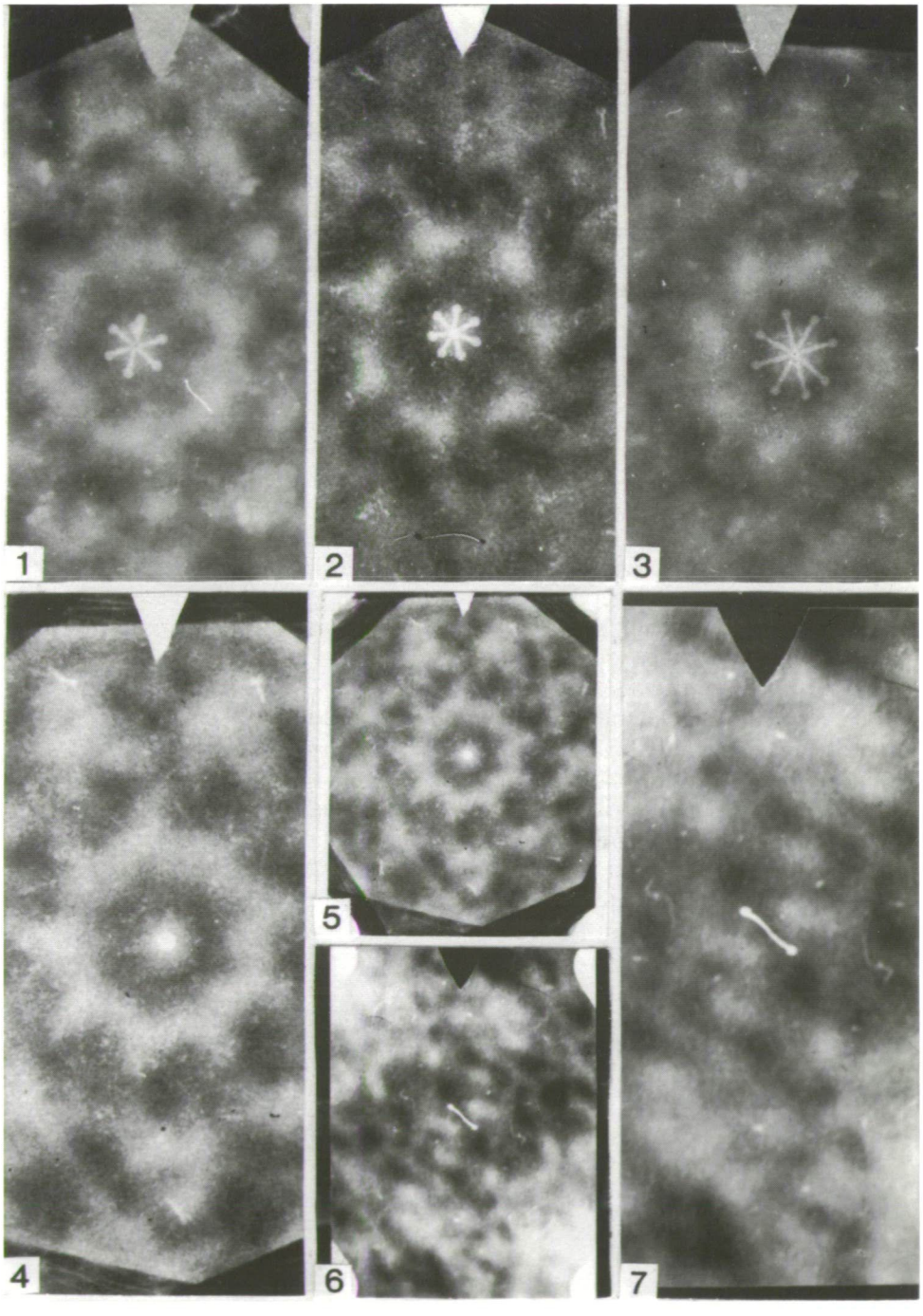
Secondary rotation picture: C.P.5.A.4.4. – C.S.$X_{2/1}$.5.5. (Plate 7.5., figs. 3,6)

Several positive and negative points of symmetry appeared in an unusual, interesting pentagonal arrangement. The delineation of the rotation area is definite.

◂ Plate 7.3

1–9. *Pinus griffithii* McCLELL. Recent. Experiment No: 79, negative no: 7451. Non-fivefold rotation pictures.

1. C.P.5.A.2.2. 500.000x.
2. C.P.5.A.2.2. 1 Million.
3. C.P.5.A.3.3. 500.000x.
4. C.P.5.A.3.3. 1 Million.
5. C.P.5.A.4.4. 500.000x.
6. C.P.5.A.4.4. 1 Million.
7. C.P.5.A.3.6. 500.000x.
8. C.P.5.A.7.7. 500.000x.
9. C.P.5.A.4.8. 500.000x.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Secondary rotation picture: C.P.5.A.3.6. – C.S.$X_{2/1}$.3.6. (Plate 7.6., figs. 1,2)

The rotation area is characteristic and sexangular. The positive and negative secondary points of symmetry are generally duplicate.

Secondary rotation picture: C.P.5.A.3.6. – C.S.$X_{2/1}$.5.5. (Plate 7.6., figs. 3,4)

The secondary points of symmetry are in a pentagonal arrangement. The delineation of the rotation area is not characteristically straight.

Discussion and Conclusions

Regarding the incomplete rotation, our methodical results can be summarized as follows:

			A	B
10/2, 1–5,	7.1.,1,2	A – B – A – B – A	3	2
10/2, 2–6,	7.1.,3,4	B – A – B – A – B	2	3
10/2, 3–7,	7.1.,5,6	A – B – A – B – A	3	2
10/2, 4–8,	7.1.,7,8	B – A – B – A – B	2	3
10/2, 5–9,	7.2.,1,2	A – B – A – B – A	3	2
10/2, 6–10,	7.2.,3,4	B – A – B – A – B	2	3

It is a normal periodicity at this kind of rotation. But when we compare the results of 10/2,1–5, 3–7, 5–9, and 10/2, 2–6, 4–8, 6–10, it is not so easy to distinguish between the similarities of these two groups. It is interesting that at all of the "half tenfold" rotations the results are almost identical with the secondary points of symmetry of a tenfold rotation. The differences can also be established in contrast to the rotation pictures.

The results of the non-fivefold rotation of the basic regular pentagonal biopolymer unit verified again the complexity of the biopolymer system of the sporoderm. To this, the three-dimensional modelling of the quasi-crystalloid biopolymer unit (KEDVES 1991b, 1992, and KEDVES, TÓTH and FARKAS, 1993, in print) contribute useful pieces of information. The arrangement of the units of biopolymer systems seems to have a lot of variations.

◂ Plate 7.4.

1–7. *Pinus griffithii* MCCLELL. Recent. Experiment No: 79, negative no: 7451.
1–5. Non-fivefold rotation pictures.
1. C.P.5.A.3.6. 1 Million.
2. C.P.5.A.7.7. 1 Million.
3. C.P.5.A.4.8. 1 Million.
4. C.P.5.A.9.9. 1 Million.
5. C.P.5.A.9.9. 1 Million.
6. Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.2.2. 500.000x.
7. Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.2.2. 1 Million.

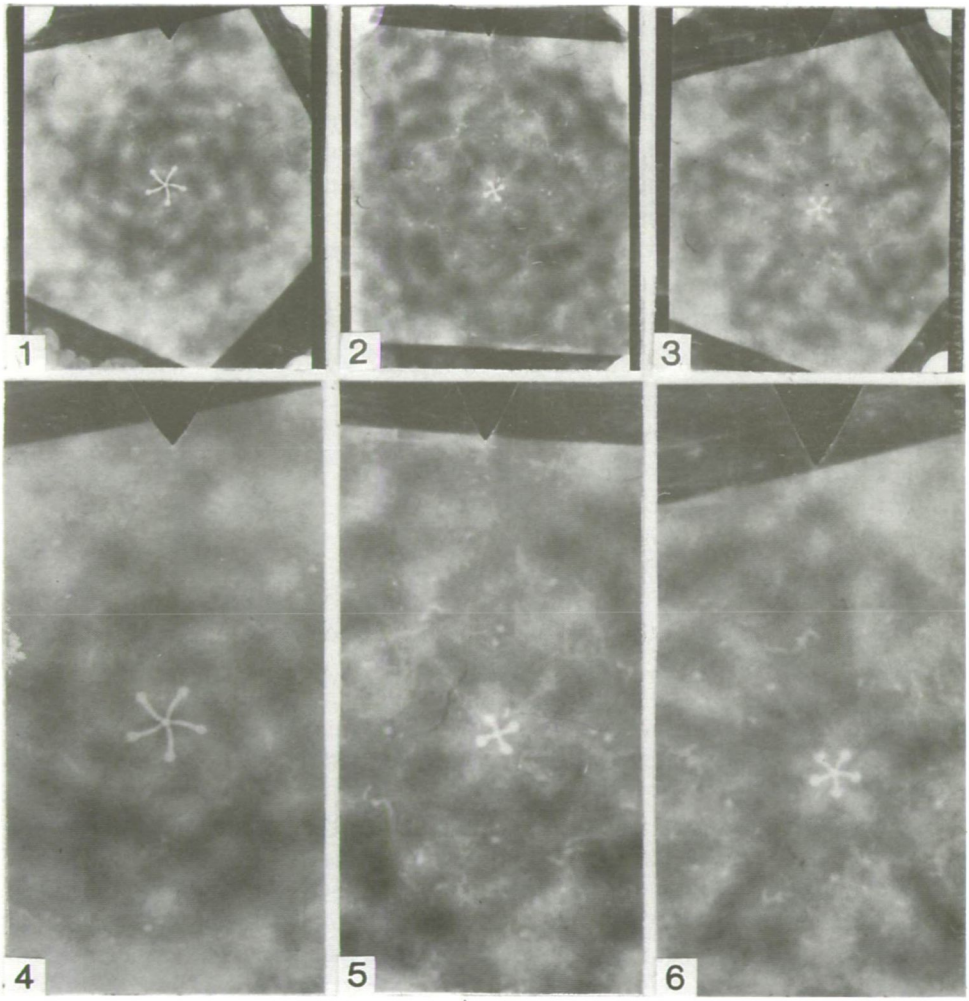

Plate 7.5.

1–6. *Pinus griffithii* McCLELL. Recent. Experiment No: 79, negative no: 7451.
1. Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.5.5. 500.000x.
2. Secondary rotation picture: C.P.5.A.4.4. – C.S.$X_{2/1}$.4.4. 500.000x.
3. Secondary rotation picture: C.P.5.A.4.4. – C.S.$X_{2/1}$.5.5. 500.000x.
4. Secondary rotation picture: C.P.5.A.2.2. – C.S.$X_{1/2}$.5.5. 1 Million.
5. Secondary rotation picture: C.P.5.A.4.4. – C.S.$X_{2/1}$.4.4. 1 Million.
6. Secondary rotation picture: C.P.5.A.4.4. – C.S.$X_{2/1}$.5.5. 1 Million.

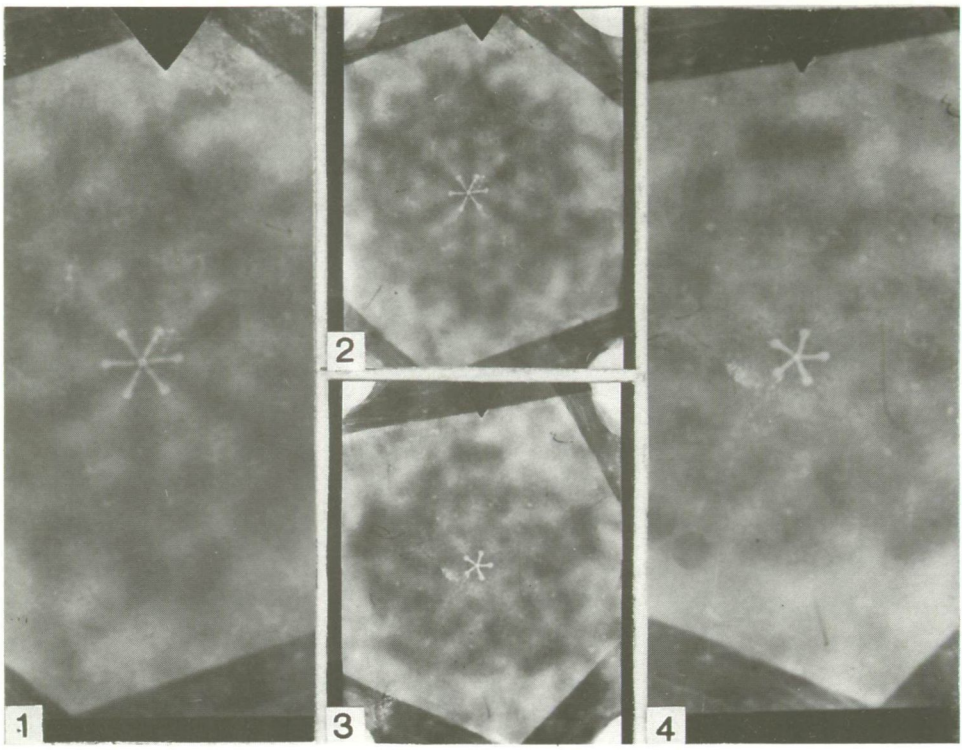

Plate 7.6.

1–4. *Pinus griffithii* McCLELL. Recent. Experiment No: 79, negative no: 7451.
1. Secondary rotation picture: C.P.5.A.3.6. – C.S.$X_{2/1}$.3.6. 1 Million.
2. Secondary rotation picture: C.P.5.A.3.6. – C.S.$X_{2/1}$.3.6. 500.000x.
3. Secondary rotation picture: C.P.5.A.3.6. – C.S.$X_{2/1}$.5.5. 500.000x.
4. Secondary rotation picture: C.P.5.A.3.6. – C.S.$X_{2/1}$.5.5. 1 Million.

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8. PREMIERS RÉSULTATS DU SYSTÈME DE BIOPOLYMÈRE STABILISATEUR DU SQUELETTE QUASI-CRISTALLOÏDE DE L'EXINE

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Sommaire

Le système biopolymère du sporoderme peut être classé en deux composants principaux: 1. Le squelette quasi-cristalloïde qui est un système metastable. 2. Le système des biopolymères stabilisateurs. Ces molécules ou associations des molécules remplissent les cavités et les frustrations – sensu NELSON – du squelette quasi-cristalloïde et empêchent la désintégration spontanée de ce système de biopolymère. Parallèlement avec l'étude du système de biopolymères quasi-cristalloïdes nous avons commencé des recherches pour éliminer le squelette quasi-cristalloïde afin d'obtenir des documents directs par MeT du système stabilisateur. Sur les photos au MeT de l'intine partiellement dégradée des pollens biailés de *gymnosperme (Pinus griffithii* MCCLELL.) on a obtenu pour la première fois des informations directes sur le système de biopolymères stabilisateurs de l'unité de PENROSE–I type squelette quasi-cristalloïde. On a établi l'hétérogénéité du système biopolymère des stabilisateurs qui sont selon nos connaissances jusqu'à présent les suivants:
1. Stabilisateur central de forme globulaire au milieu de l'unité centrale (pentagone-dodécaèdre) du squelette de PENROSE–I. Le système du squelette qui entoure le pentagone-dodécaèdre a aussi un stabilisateur central. Mais les relations entre ces deux stabilisateurs centraux ne sont pas encore bien connues.
2. Les frustrations et les autres cavités du squelette quasi-cristalloïde sont remplies par des systèmes de biopolymères, lamellaires ou fibrillaires. Pour mettre en évidence ce système de biopolymère stabilisateur dans les cadres du squelette quasi-cristalloïde nous venons d'élaborer une méthode. Les premiers résultats dans ce sujet présentés dans cette contribution.

Mots clés: Palynologie, actuel, structure biopolymère, stabilisateur.

Introduction

L'étude multidisciplinaire du paroi extrêmement résistant des spores et de grains de pollen a été le sujet depuis longtemps de plusieurs études. Une énorme quantitée de publications ont paru avec des conceptions différentes. Vue l'état actuel de nos connaissances dans ce sujet, il nous semble important de distinguer très nettement deux sortes d'études suivant les méthodes fondamentales de la recherche: 1. Les recherches des précurseurs ou en général des composants chimiques, en utilisant les méthodes de la chimie et de la chimico-physique. 2. Le système des biopolymères ou des sous-unités de l'exine, qui peuvent être étudiés par la microscopie électronique à transmission après le processus de la dégradation partielle. Suivant la mesure de la

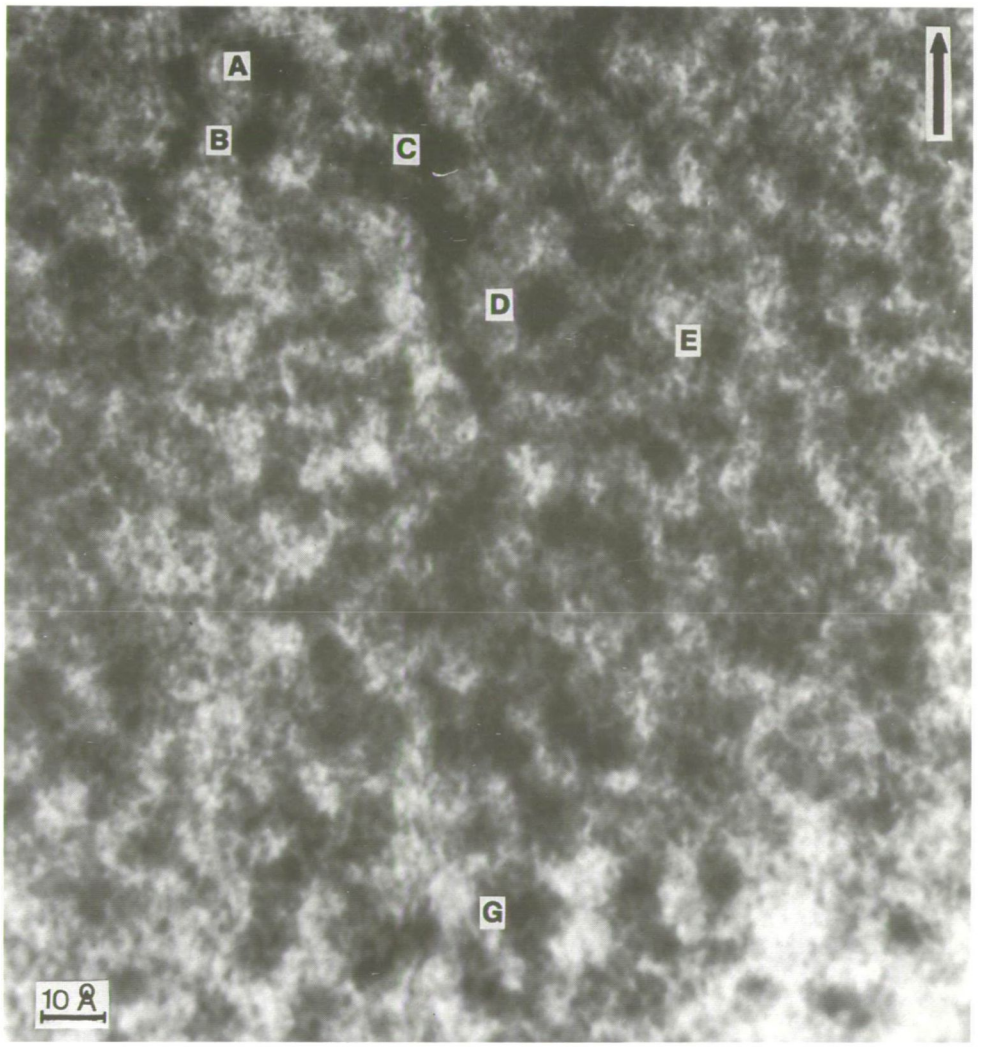


Planche 8.1.

Pinus griffithii McCLELL.
Détail du système de biopolymèr de l'intine partiellement dégradée, par expériment no: 681. No du négative: 430. Plusieurs sortes d'unités de biopolymères sont illustrées. Les globules de diamètre de 6 à 8 Å sont probablement les stabilisateurs centraux d'un pentagone dodécaèdre du PENROSE–I type squelette quasi-cristalloïde. Il y a encore de deux sorte supplémentaires de biopolymères globulaires, les plus petites représentent les "ombres" des atoms. Le système de biopolymères de forme circulaire autour du stabilisateur central remplissent les cavitées des "frustrations" concentriques internes. La diamètre de ces circles est de 32,4 à 33,2 Å. Ce système est particulièrement net autour du stabilisateur central "D". Toutes les unités centrales qui ont été utilisées pour des études supplémentaires sont indiquées par des lettres de "A" à "I".

dégradation partielle, on a pu établir des degrés différents dans l'organisation du système de biopolymère, cf. KEDVES (1989a). La base est l'unité de biopolymère de forme de pentagone régulier dans la dimension des angstroems (8–20 Å environ). Ces éléments composent le squelette quasi-cristalloïde qui est le sujet de plusieurs études (cf. GÉVAY et KEDVES, 1989, KEDVES 1989a,b, 1990, 1992, KEDVES, TÓTH et FARKAS, 1992). Ces composants constituent sur un degré supérieur des "sous-unitées" comme les structures hélicoïdales ou tubulaires (ABADIE, HIDEUX et ROWLEY, 1986–1987, FLYNN et ROWLEY, 1971, ROWLEY, 1990, ROWLEY, DAHL et ROWLEY, 1981, ROWLEY, DAHL, SENGUPTA et ROWLEY, 1981, ROWLEY, EL-GHAZALY et ROWLEY, 1987), les polygons irréguliers (SOUTHWORTH, 1985a,b, 198a,b) et les éléments globulaires de HESSE (1985). Les structures qui sont similaires aux cristaux colloidaux publiés par HEMSLEY, COLLINSON et BRAIN (1992) peuvent être classées aussi sur ce niveau.

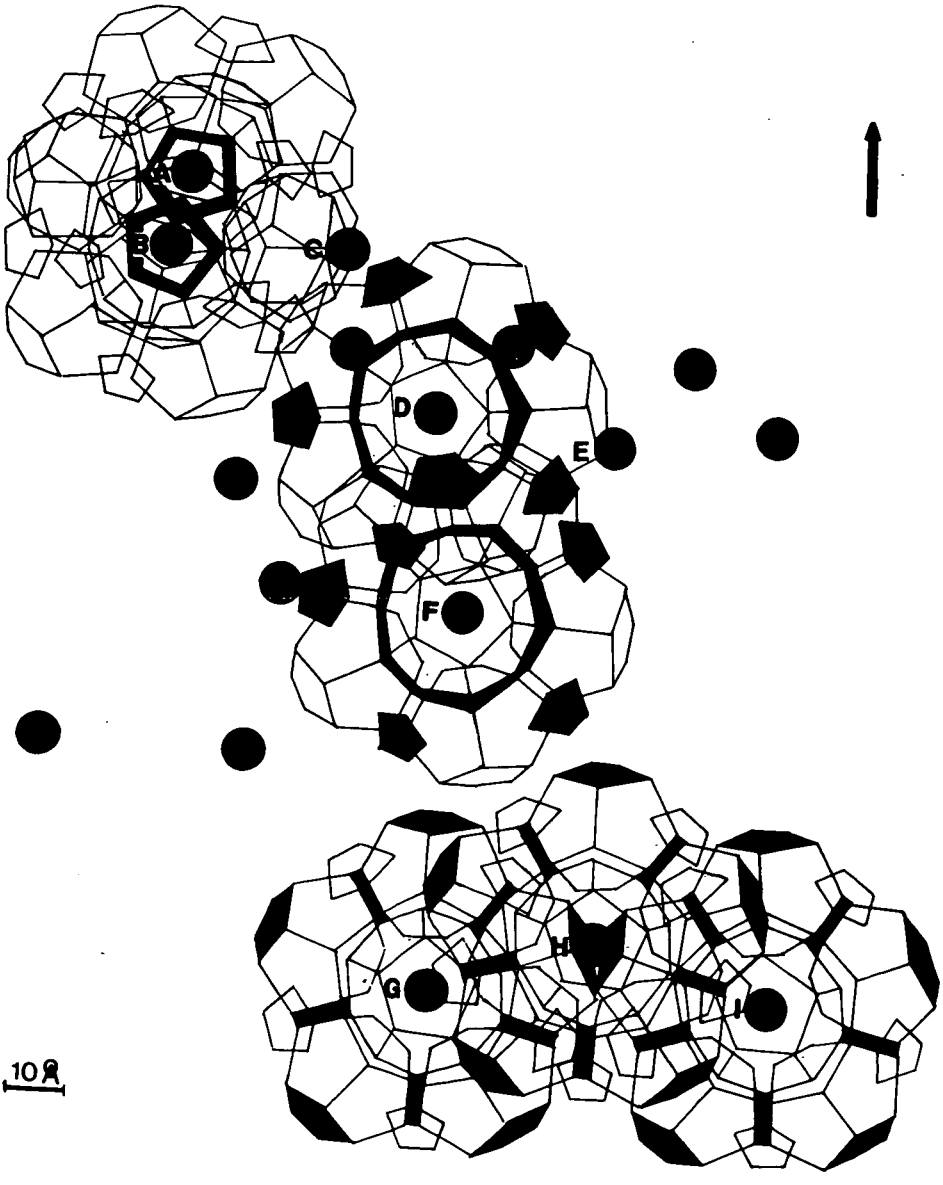
Du point de vue du sujet de notre étude, les structures quasi-cristalloïdes sont les plus importantes. Suivant les résultats les plus récents, cette organisation peut se rencontrer sur le niveau des molécules aussi (cf. KEDVES, TÓTH et FARKAS, 1992), mais elle n'est jamais connue sur le niveau des sous-unitées de l'exine de dimension de nanomètre.

Comme nous l'avons déjà fait remarquer, le squelette de biopolymères quasi-cristalloïdes représente une structure metastable, et par la désintegration de ce système une énergie remarquable peut être libérée. Une complexité des biopolymères remplissent les cavitées du squelette quasi-cristalloïde, en assurant la stabilisation relative du paroi sporal. Nous les appelons stabilisateurs. Pour avoir des documents directs de ce système des associations des molécules il est nécessaire de dissoudre le squelette quasi-cristalloïde. Plusieurs essais ont été faits et, en se basant aux résultats de nos expériments jusqu'à maintenant, il nous semble que c'est plus difficile que la dissolution des biopolymères stabilisateurs.

Ce travail va présenter pour la première fois les données directes par la méthode de la microscopie électronique à transmission des stabilisateurs du système quasi-cristalloïde de PENROSE–I type de système biopolymère. Ensuite on a commencé à élaborer une méthode pour l'étude et l'interprétation de l'arrangement des unitées stabilisateurs de biopolymères. Il y a lieu de souligner qu'il y a encore beaucoup de choses à faire dans ce sujet, en ajoutant que même le système quasi-cristalloïde n'est pas encore suffisamment connu en tous les détails.

Matière et Méthode

Les grains de pollen de *Pinus griffithii* MCCLELL ont été le sujet de ces études, par expériment No 681. La dégradation partielle a été effectué par diethylether, la méthode en détail a été publiée précédemment, cf. KEDVES et PÁRDUTZ (1992). Comme on a déjà fait remarquer, les négatives ont été prise par un appareil de MeT Opton EM-902 dans le Laboratoire de Microscopie Electronique de l'Institut de Biophysique du Centre de Biologie de l'Académie des Sciences de Hongrie. La négative (No: 430) a été prise au grossissement de 400.000 de l'intine de grain de pollen partiellement dégradée. Il y a lieu de remarquer que sur cette négative on a observé l'image des molécules, et parmi celles-ci une de forme de pentagone a été le sujet des opérations de symétrie, cf. KEDVES, TÓTH et FARKAS (1992).


A
B
C
D
E
F
G
H
I
10 Å

Résultats

Pour avoir une aspect général, on a préparé des photos au grossissement de 5 Million de la négative entière. Sur cette grande photo laquelle a été composée de plusieurs parties on a pu observer très clairement des unités globulaires de plusieurs dimensions. Pour la publication nous avons utilisé des photos à 1 Million (Planche 8.1.). Certaines, mais en particulier une ("D") est entourée d'un système de biopolymère de forme circulaire. Un système biopolymère similaire, mais pas tellement complet a été encore observé ("B, F, G, H"). Nous avons pensé que les unités globulaires grandes, de taille de 6 à 8 Å, sont les unités stabilisatrices centrales, qui se placent au milieu du pentagon-dodécaèdre central d'un PENROSE–I type squelette de biopolymère.

Pour étudier la dispositon de ces unités de biopolymères dans le système entière, comme premier essai pour la méthode de recherche nous avons effectué les démarches ci-dessous:

1. En tenant compte des unitées de biopolymères représentées sur la Planche 8.1., et les schémas (Fig. 8.1. et 8.2.), ensuite en se basant sur nos résultats antérieurs concernant le squelette quasi-cristalloïde en deux mais en particulier en trois dimensions, nous avons pris pour base la photo prise du modèle de PENROSE-I type quasi-cristalloïde squelette à trois dimensions. Comme nous l'avons déjà fait remarquer, nos modèles à trois dimensions ont été préparés dans l'échelle des unités de biopolymères observées sur les premières photos de MeT. De la photo, prise en face du modèle à trois dimensions de PENROSE-I type squelette, nous avons préparé des schémas dans la mesure de 5 et de 1 million. Voir ce dernier sur la figure 8.1. et 8.2.
2. Ce schéma pensons-nous représente le squelette quasi-cristalloïde de PENROSE-I type unité en deux dimensions.
3. Ensuite nous avons placé ce schéma au milieu d'en biopolymère globulaire (qui est selon notre hypothèse le stabilisateur central du PENROSE-I unité), et ensuite tourné jusqu'à la position ou le maximum des unités voisines soit en symétrie avec le schéma du squelette (Fig. 8.1. et 8.2.).

◂ Fig. 8.1.

Pinus griffithii MCCLELL.

Schéma préparé de la photo de la planche 8.1., indiquant l'emplacement du système biopolymère des stabilisateurs centraux. Un autre type de schéma qui a été préparé d'une photo pris d'un modèle à trois dimensions d'une unitée de type PENROSE–I squelette dans la même échelle de la photo; au grossissement d'1 Milllion Plusieurs sortes de connexions du squelette quasi-cristalloïde avec les stabilisateurs sont représentées.

Connexion de type I.: Exemple: Biopolymères "A" et "B". C'est la connexion la plus enchainée. Les stabilisateurs centraux des unitées connectées du PENROSE–I type squelette se placent sur les systèmes de biopolymères circulaires. Voir encore deux unitées globulaires autour du biopolymère "D".

Connection de type II.: Exemple: Biopolymères "G", "H" et "I". Dans ce cas-lá, le contour extérieur du squelette de type PENROSE–I touche le centre (le pentagone ou le stabilisateur central) du squelette voisin.

Connection de type III.: Exemple: Biopolymère "B" et "D". Les contours extérieures sont en connexion de deux squelettes de PENROSE–I type voisin.

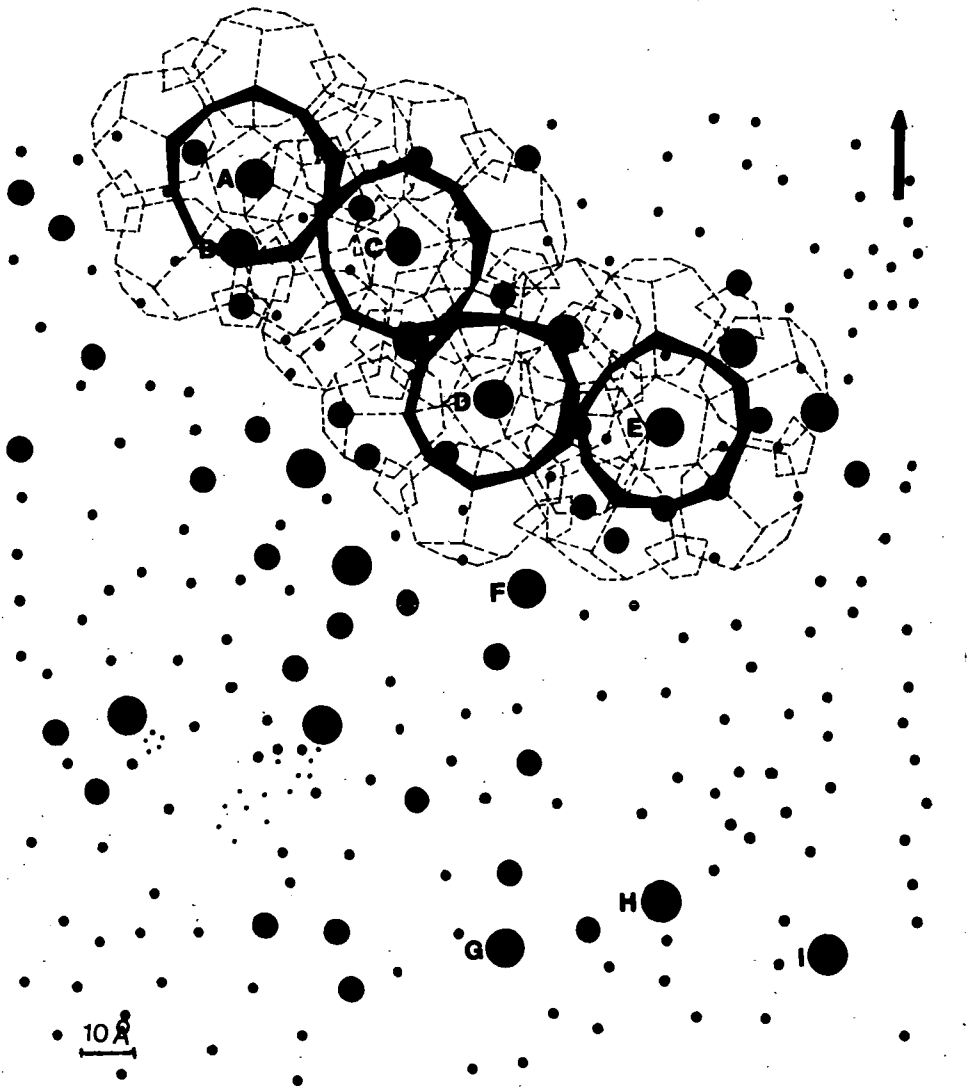


Fig. 8.2.

Pinus griffithii McCLELL.
Schéma préparé de la photo de la planche 8.1., indiquant tous les points de symétrie importants. Les squelettes de type PENROSE–I des biopolymères stabilisateurs centraux "A", "C", "D" et "E" sont indiqués. Il est à remarquer que suivant ces schémas les stabilisateurs circulaires sont en connexion.

4. Suivant cette méthode, nous avons pu distinguer pour le moment trois positions principales des unités de PENROSE-I type squelette y compris leur stabilisateur central.

4.1. Connection de type I (Fig. 8.1. "A" et "B")

C'est la connection la plus proche entre deux unitées. Il est à remarquer que les pentagones centraux avec les unités "A" et "B" sont en position particulière. Un sommet de tous les deux pentagones atteint le stabilisateur central voisin. En analysant cette partie de schema ("A" et "B", fig. 8.1.) on peut établir encore des symétries intéressantes supplémentaires.

4.2. Connection de type II (Fig. 8.1., "G", "H" et "I", et fig. 8.2., "A", "C", "D" et "E")

Ces connections dans les cas typiques peuvent être caractérisées avec les traits ci-dessous:

Les systèmes de biopolymères stabilisateurs circulaires voisins sont en connexion tangentielle (Fig. 8.2.).

D'autre part, le contour avec un losange périférique du schéma du squelette PENROSE-I touche le stabilisateur voisin.

Il y a deux sortes de conditions pour ce type de connexion:

1. Une distance convenable entre les deux stabilisateurs centraux; A – C = 29 Å, C – D = 33 Å, D – E = 31 Å, G – H = 28 Å, H – I = 32 Å.

2. L'angle de trois stabilisateurs voisins semblait aussi important; AC – CD = 144°, CD – DE = 130°, GH – HI = 145°.

Nous avons trouvé une connexion pas typique, voir D et F, fig. 8.1. Les systèmes de biopolymères stabilisateurs circulaires ne se touchent pas, mais les angles extérieurs du schéma sont en connexion avec le pentagone central voisin.

4.3. Connection de type III (Fig. 8.1., "B" et "D")

Dans ce cas-là les contours extérieurs sont en connection tangentielle.

5. Pour avoir des aspects plus amples concernant la compléxité du système biopolymère du paroi pollinique, nous avons mis en évidence certains éléments de la symétrie, en particulier sur la fig. 8.1.

Discussion et Conclusions

1. Comme nous avons déjà fait remarquer c'est le premier document direct concernant le système de biopolymère stabilisateur du squelette quasi-cristalloïde. Suivant nos résultats précédents sur le squelette quasi-cristalloïde, il est évident que le système stabilisateur est beaucoup plus complexe que nous n'avons pu le mettre en évidence jusqu'ici. En effet nous avons des informations de deux sortes de stabilisateurs seulement.

2. La méthode présentée ici est aussi pour une sorte de système biopolymère. Par exemple pour les éléments lamellaires ou en particulier le système biopolymère de la surface il faut élaborer une autre méthode.

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Key words: Palynology, research fields, review, Hungary.

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Key words: Palaeobotany, new methods, biopolymer oranization.

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Key words: Sporopollenin, quasi-crystalloid biopolymer structure, organizations model.

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Key words: Organic Geochemistry, kerogens, biological precursor material.

A photograph of Prof. Dr. C. ALVAREZ RAMIS in the office of Dr. M. KEDVES. The picture was taken by Dr. É. SIPOS-KEDVES.

Chronicle

Compiled by

M. KEDVES and I. GÁSPÁR

Visiting scientists

Dr. Bogomir JELEN, Senior Research Associate (Geological Survey of Ljubljana, Institute for Geology, Geotechnics and Geophysics, Ljubljana, Republic of Slovenia), visited the laboratory from 18th to 23th January, 1993. The aim of his visit was to work out the partial results of the joint research program dealing with the following Paleogene layers: Sava Folds (Zagorje-Lacko Syncline), Lower "Socka Beds", coal, Upper "Socka Beds", Oligocene Marine Clay.

Prof. Dr. C. ALVAREZ RAMIS (Department of Paleontology, Faculty of Geology, U.C.M. Madrid, Spain), spent two weeks in Szeged from 28th May to 11th June, 1993 and worked on the preparation of the publication of the results of the joint research program: "Estudio de diversos aspectos paleobotánicos del Cretácico superior del Cerro de la Mesa, Norte de la provincia Madrid."

On the 1st June, 1993 she took part in the scientific session organized in Budapest by the Biological Department of the Hungarian Academy of Sciences on the occasion of the 85th birthday of Prof. Dr. B. ZÓLYOMI academician, establisher of the Hungarian Quaternary Palynology. Prof. Dr. M. KEDVES and A. VÉR represented the laboratory on this event.

Dr. Bogomir JELEN visited again the laboratory in December (13–17, 12, 1993) and worked out the first part of the previously mentioned program for publication.

International laboratory activity

20–22 May, 1993 – Berlin

Scientific meeting dedicated at the occasion of Prof. Dr. W. KRUTZSCH's 65th birthday, organized by Prof. DR. R. DABER (Museum für Naturkunde, Berlin) and Dr. H. BLUMENSTENGEL (Geologisches Landesamt Sachsen-Anhalt, Berlin).

KEDVES, M.: Multidisciplinary characters of Palaeopalynological researches.

27 August–5 September, 1993 – Yokohama

XVth International Botanical Congress, Yokohama, Japan. Dr. M. KEDVES took part in the congress as an invited speaker in the section S1.8.1., "The Contribution of Pollen and Spore Studies to Systematic and Evolutionary Biology (Stephen BLACKMORE, Masamichi TAKAHASHI);

KEDVES, M., TÓTH, A. and VÉR, A.: Radial Fivefold Rotation: A New Method in the Study of the Biopolymer Organization of the Sporoderm.

18–26 September, 1993 – Besançon

The XIIIth Symposium of the A.P.L.F. "Palynologie et évenements cycliques" Besançon, 20–24 September, 1993, France.

KEDVES, M. et BAGI, I.: Études palynologiques et pédologiques sur les sédiments Holocènes de la piscine du monastère du Mont Jakab.

11–25 October, 1993 – Madrid.

Prof. Dr. M. KEDVES worked in the Department of Paleontology (Facultad de Ciencias, Universidad Complutense de Madrid) in Madrid as a visiting scientist together with Prof. Dr. C. ALVAREZ RAMIS and Dr. M. T. FERNÁNDEZ MARRÓN. They closed the previously mentioned joint research program, considered the final results and prepared a new joint research program.

Laboratory meetings

5. 2. 1993, speaker: KEDVES, M.: Discussion of the up-to-date research programs of the laboratory.

2. 4. 1993, 1. speaker: GÁSPÁR, I.: Review of two papers written about recent and fossil *Equisetum* spores.

2. speaker: VÉR, A.: Discussion of her certificate dissertation.

3. speaker: KEDVES, M.: Actual problems.

12.11.1993, speaker: KEDVES, M.: Report on the XIIIth Symposium of the A.P.L.F. "Palynologie et évenments cycliques". 20–24 September, 1993, Besançon, France.

22. 12. 1993, speaker: KEDVES, M.: Discussion of the participation of the laboratory on the international scientific meetings in 1994.

Preparation of the next number of the laboratory bulletin.

Teaching program of the laboratory

During the two semesters in 1993 the following lectures were delivered:

Introduction to the plant micropaleontology of pre-Quaternary deposits, 1+2 hours weekly.

Organization levels of the biopolymer system of the plant cell wall, 1+2 hours weekly.

Theory of the evolution and its natural phylosophical relations, 1 lecture weekly.

Personalia

Anita TÓTH is one of the establisher of our laboratory. She has worked here with a great diligence and persistently since she was a grammar-school student. Later she attended to the Szentgyörgyi Albert Medical University in Szeged and now she is in her fourth year. On 3rd October, 1992 she married and gave birth to her daughter, Viola on 2nd April, 1993.

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